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ORIGINAL ARTICLES.

I.—Note on the Reconstruction of *Iguanodon* in the British Museum (Natural History), Cromwell Road.

By Henry Woodward, LL.D., F.R.S., Pres.G.S.

(PLATE X.)

BY the kind assistance of Monsieur E. Dupont, the Director of the Royal Museum of Natural History in Brussels, a coloured reproduction of the entire skeleton of *Iguanodon Bernissartensis* has lately been acquired for the British Museum (Natural History), and may now be seen admirably set up in the Reptile Gallery of the Geological Department.

Remains of *Iguanodon* had long been known from deposits of Wealden age in this country, the first notice being that by Dr. G. A. Mantell in 1825 (see Phil. Trans., p. 184). All the English accounts were founded upon teeth and detached bones of various individuals, mostly from Hastings, Sussex, from Maidstone, Kent, and from the Isle of Wight; but no complete specimen was ever obtained in this country. Many species have been established upon these very imperfect remains, but originally they were all referred to a single species, for which the names *I. anglicum*, F. Holl (1829), and *I. Mantelli*,[1] H. von Meyer (1832), were proposed. The latter, having been defined by Owen in 1851, is the species generally recognized in this country.

How imperfect was our acquaintance with the entire animal may be seen from the restoration set up about forty years ago by Waterhouse Hawkins (after Owen's suggestions) in the grounds of the Crystal Palace, Sydenham. At length our knowledge of this very remarkable reptile was destined to be perfected by the discovery, in 1878, of no fewer than twenty-three more or less complete skeletons of *Iguanodon* at Bernissart in Belgium, where heretofore no Wealden strata had been known to exist.

At this village, between Mons and Tournay, near the French frontier, coal-mining had been carried on for years by M. Fages, Director-General of the Society of Bernissart. A trial gallery, made in order to discover the continuation of a missing seam of coal, led to the finding of an ancient river-gorge, excavated by a stream in

[1] For an account and restored figure of Mantell's *Iguanodon* see Geol. Mag. 1885, Dec. III, Vol. II, pp. 10–15, Pl. I, by H. Woodward.

the Jurassic period through several hundred feet of Coal-measures, but since filled up and all trace of its existence obliterated on the surface. On the discovery of the fossils M. Gustave Arnould, the principal engineer of the coal-pit, immediately informed M. Dupont, Director of the Brussels Museum, who at once sent M. Depauw, the Chief Superintendent of the Modellers' Department, to undertake the extraction of the bones, which were numerous and of gigantic size.

They are preserved in a blackish clay, which filled the valley to a great extent, and was no doubt of fluviatile origin. The associated fossil-remains tell us of an old land-surface covered with cycads, arborescent ferns, and other semi-tropical plants of the Wealden period.

The river must have been well stocked with fishes, especially those of the genus *Lepidotus*, having thick enamelled scales, reminding one of the American bony pike, but with a very different form of head, and with rounded crushing palatal teeth. The banks of the stream formed the home of lizards, crocodiles, water-tortoises, and the huge *Iguanodon*. Thick vegetation of ferns and giant Equisetaceæ clothed the margins of the river, and we can easily realize that in times of flood, which were not infrequent, the *Iguanodon*—and the plants they fed upon—together with crocodiles, water-tortoises, and the fishes of the stream, were all entombed in one common grave and covered up by deposits of fine mud left behind by the river-flood. Evidence of no fewer than four of these freshets was observed by M. Dupont in the course of these explorations.[1]

The exhumation and removal from the mine of these ponderous remains occupied two years. The subsequent development and setting up of the five individuals exhibited in the Brussels Museum was a far longer and still more critical labour. The work of description, commenced in 1881 by Mr. G. A. Boulenger, was continued by M. L. Dollo, in great detail, with admirable figures (see Bull Mus. Roy. Hist. Nat. Belge 1881–82).

Although three entire wall-cases and two table-cases are devoted to the exhibition in the British Museum (Natural History) of the remains of the *Iguanodon* from British localities, they nevertheless fail to impress one with the same degree of interest which is felt in the presence of the huge skeleton which now forms so conspicuous an object in the central floor-space of the Reptile Gallery.

The specimen set up is a coloured reproduction by M. Depauw of one of the five entire skeletons exhibited in the Royal Museum of Natural History in Brussels, which he has worked out and reconstructed with such consummate skill. The skeleton measures 15 feet in height, and 30 feet from the head to the extremity of the tail. It is set up in the position in which it is believed the animal commonly walked.

The *Iguanodon* was a vegetable-feeding reptile, and its cheek-teeth, which exceed 80 in number, were well adapted for chewing

[1] Bull. Acad. Roy. de Belgique, 2nd Serie, Tome 46, 1878, pp. 387–408.

the leaves and shoots of the Cycadaceous and other plants which formed its diet. It had no front teeth, but its jaws were provided with a horny beak, like that of a turtle, covering the border of the premaxilla and of the predentary bone.

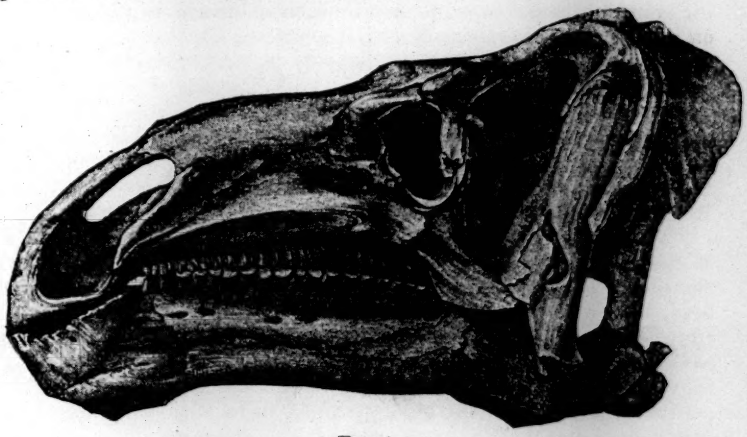


Fig. 1.

Left lateral aspect of skull of *Iguanodon Bernissartensis* (Boulenger); from the Wealden of Bernissart, Belgium (much reduced). The anterior aperture in the skull is the nares (nostril), the middle one the orbit, and the large posterior one the infratemporal fossa. The predentary bone is seen at the extremity of the mandible (after Dollo).

The fore-limbs are shorter than the hind ones, the former being six feet in length and the latter nine feet long. The hands had each five digits with nails, the thumbs being armed with strong, sharp-pointed, conical spurs. They appear to have been but ill-adapted for progression on the ground, though doubtless when browsing on lowly herbaceous plants the *Iguanodon* assumed the same quadrupedal attitude as does the living kangaroo.

The hind-limbs were large and powerful, and had three toes on each foot, with the same number of phalanges as in a bird's foot, namely, three to the inner toe, four to the middle toe, and five to the outer toe. The three metatarsal bones remain separate and distinct as in the foot of a young ratite bird, not anchylosed together as in adult modern birds. The bones of the pelvis (ilium, ischium, and pubis) resemble in many respects those of a large running bird, such as the emeu.

The ponderous tail, as well as the neural spines of the dorsal vertebræ, were strengthened and knit together by numerous stout bony fibres, no doubt giving great additional support to the animal when standing in an erect position; the length of these spinous processes also must have given the tail great depth, and suggests that probably the *Iguanodon* was a good swimmer, using its tail as a rigid, powerful, oar-like propeller by moving it from side to side.

Numerous three-toed footprints of the *Iguanodon* were discovered

by Dr. Mantell, Mr. S. H. Beckles and others, preserved on the surfaces of the slabs of Hastings sandstone. These always show a single bipedal track, and may therefore be considered as good evidence that the *Iguanodon* ordinarily walked in an erect position.

Several of these footprints may be seen exhibited in the wall-case on the east side of Gallery No. xi.

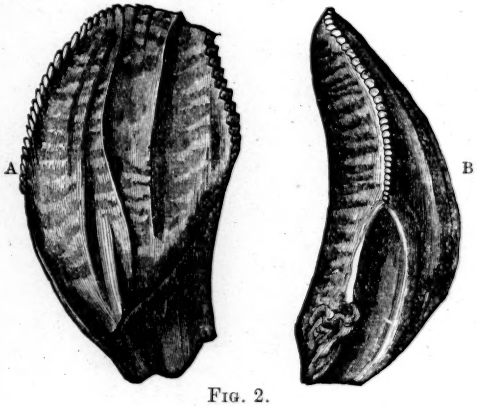


Fig. 2.

(A), Outer view; (B), profile of tooth of *Iguanodon* (natural size), Wealden, Isle of Wight.

In Wall-cases 4*a* and 6, and in Table-cases Nos. 8 and 9, may be seen many examples of portions of the maxillæ and mandibular rami with the worn and unworn teeth of *Iguanodon in situ*, showing their curious curved and leaf-shaped pattern, with the edges elegantly serrated in a manner peculiar to the vegetable-feeding dinosaurs.

In a separate case placed in the centre of the floor near the skeleton, is exhibited a restored reproduction of the skull, of which we give a figure showing the remarkable length of the row of cheek-teeth, reminding one, superficially, of the jaw of the horse, but the mode of suspension of the mandible by the large quadrate bone is unlike that seen in the mammalia. The great horse-shoe shaped predentary bone can also be clearly seen in this specimen.

II.—On the Mode of Occurrence of Eozoon Canadense at Côte St. Pierre.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., etc.

THE question of the origin of Eozoon Canadense has been recently revived in an important and most interesting paper on a similar structure in blocks of limestone ejected from Vesuvius.[1] The

[1] Eozoonal structure of the ejected blocks of Monte Somma. By Prof. H. J. Johnston-Lavis, M.D., and J. W. Gregory, D.Sc. Trans. Roy. Dubl. Soc., ser. ii, vol. v, p. 259. Sir J. W. Dawson's views are very fully stated in two sections of his work "Salient points in the Science of the Earth" (1893). [June 12. This paper was finished before a type-written copy of his paper, printed in the last Number of this Magazine (p. 271), reached me. To this I could not refer, because I did not know where, or in what form, it would be published.—T. G. B.]

writers, however, of that paper evidently found that more information existed as to the microscopic structure of the Canadian Eozoon than as to its mode of occurrence, so that a few notes on this subject may be of some use as a contribution to the discussion. I visited one of the most noted localities for Eozoon—Côte St. Pierre—in 1884, when I had the inestimable advantage of being conducted by Sir J. W. Dawson, to whose unwearied kindness and hospitality I was so often indebted during my stay in Canada. I made careful notes and rough sketches of what I saw, collected a fair suite of specimens, and paid especial attention to the relation of the structure to other parts of the rock-masses. Upon the question of the origin of Eozoon I do not purpose to enter: I shall restrict myself to stating facts of which, as it seems to me, account must be taken in all attempts to interpret this extraordinary structure.

Côte St. Pierre is a scattered settlement—one can hardly call it a hamlet—as far as I remember, about twelve miles from Papineauville, on the railway between Montreal and Ottawa. At the station a shallow cutting exhibits an interesting section[1] of Laurentian rocks—marble, calc-mica schist, and biotite-hornblende schist, with a vein of pegmatite—all coarsely crystalline, between two masses of gneiss, the higher of which is finer in grain than the lower. The road to Côte St. Pierre traverses an undulating or slightly hilly district, consisting of gneisses belonging to the upper group, which are often masked by a thin covering of sands and clays (Pleistocene). There are still very considerable tracts of uncleared forest. The crystalline rock, in general character (I did not attempt a minute study), was a distinctly foliated, moderately fine-grained reddish gneiss. This, at the time reminded me of some from the Central Highlands of Scotland, which I had recently examined for Dr. Hicks, and to which he assigned a fairly low place in his succession.[2] The rock is moderately schistose, but in general is strong and not friable.

We kept along the upper series of gneisses, as I was informed, till we arrived at Côte St. Pierre. The cottages are scattered about a rather open and shallow valley, perhaps a quarter of a mile wide; the bed, except where there is a large pool, being nowhere quite flat. On the western, or right, bank is a forest-clad flattish ridge, formed by the lower group of gneisses; on the eastern a similar ridge, consisting of the upper group. The limestone, according to Sir J. W. Dawson, occupies the whole of the valley, and its thickness was estimated by Sir W. Logan as about 500 feet.[3] We spent some hours in examining sundry outcrops of the crystalline limestone (all, I believe, which are of importance), traced the lower gneiss for some distance downwards, and just glanced at the upper gneiss. My description will be, I hope, more intelligible if I follow the apparent stratigraphical order and not that in which the notes were made.

The lowest rock visited was a rather dark, somewhat streaky,

[1] Described briefly in Presidential Address to the Geological Society, 1886, vol. xlii Proc., p. 82.

[2] Quart. Journ. Geol. Soc. (1883), vol. xxxix, p. 159.

[3] This is a minimum. It may be much more. He gives it in places 1500 feet.

biotite or biotite-hornblende gneiss, moderately fine-grained, over which comes a band of no great thickness, of a whitish quartzose rock, of which a more minute description will be given below. It is one of the so-called Laurentian quartzites. Above this comes a very considerable thickness of darkish gneiss, rather variable in character. Sometimes it is coarser, sometimes finer; sometimes there is a fair proportion of quartz, sometimes little; sometimes hornblende dominates over the biotite, sometimes the rock is distinctly banded, with more and less felspathic layers.[1] The highest rock seen was a dark, rather micaceous gneiss, of moderate-sized grain.

A short interval of covered ground separated the last-named rock from a mass of nearly pure pyroxene rock consisting of a coarsely crystalline greyish-buff pyroxene[2] with some interstitial pale-reddish garnet and light-coloured mica (associated), a little calcite, etc. In this rock are veins of an asbestiform mineral which has been worked for "rock cotton," and above this comes the crystalline limestone. The last nowhere affords a continuous section, but occurs in a number of irregular and separate outcrops on the slope and floor of the valley. As the exact relation of these is not easily determined, it will be better to deal with the principal masses.

The first is on the western slope of the valley, in immediate sequence with the rocks mentioned above. A number of shallow pits have been opened in a wood, and the limestone can be traced down to the road leading into the "hamlet." In one of these pits the dip was about 70° to a point 10° or 15° S. of E. The rock varies considerably in character. Sometimes it is nearly pure calcite (or dolomite),[3] sometimes it contains grains, more or less abundantly, of pyroxene or serpentine, which occur either in fairly marked bands or merely scattered. Pyroxenite (greyish) or serpentine (lightish-green) occurs locally in irregular nodular masses or interrupted layers, like chert in a limestone. Well-defined Eozoon is not abundant; indeed, regarding the mass as a whole, it is the exception rather than the rule. This structure commonly forms a kind of band, which is founded upon (if the phrase be permissible) a layer of green serpentine (resembling that in the well-known Connemara ophicalcite) usually not exceeding half an inch in thickness, under which comes a whitish pyroxene, but sometimes the one mineral, sometimes the other, is apparently absent. In the neighbourhood of the "foundation" the layers of calcite and serpentine in the Eozoon are often slightly thicker and less regular than in the outer part. The whole band exhibiting the structure generally varies in thickness from about two to four inches; it appears to pass, rather rapidly, but not always with a sharp boundary, into an

[1] One of my specimens, taken as a sample of about the coarsest type, might be called a quartz-diorite; hornblende is abundant in crystals about a quarter of an inch in length.

[2] The pyroxene is always light-coloured, apparently either malacolite or a closely allied variety, but occasionally it might be tremolite (*i.e.* a variety of hornblende).

[3] Some of my slices show that a little dolomite is present, but, so far as I can tell, calcite is the dominant mineral.

ordinary crystalline limestone, containing, usually, numerous granules of serpentine, which sometimes exhibit a very distinct banding resembling a stratification. Thus the structure may form an "aureole" round a nodular mass of serpentine or pyroxene, but it may also occur upon a mere band or irregular seam of serpentine. In the latter case the structure may take a very irregular curved shape, but whether this was original or due to subsequent bending I could

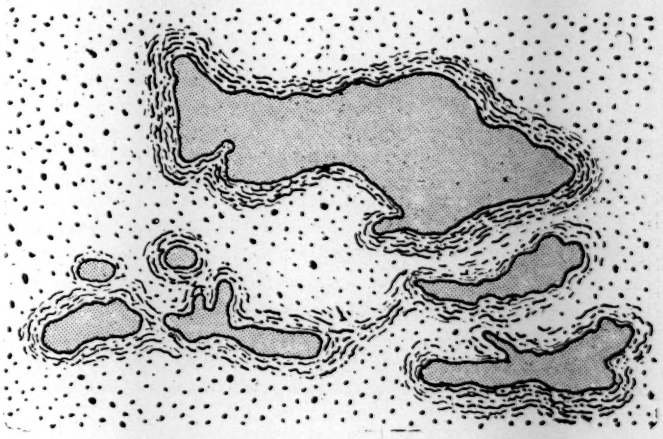


FIG. 1.—Diagram of Eozoonal Rock at Côte St. Pierre.

The closely dotted part is pyroxene or serpentine; the top mass being about 2 feet 3 inches long. The zones of "Eozoon" are indicated by the broken wavy lines, generally surrounding these masses. The remainder of the rock is white crystalline limestone, spotted with granular serpentine.

This figure appeared in my book entitled "The Story of our Planet," and I am indebted to the liberality of the publishers and proprietors, Messrs. Cassell and Co., for the cliché of the block to illustrate this paper.

not determine. The smaller masses, as Sir J. W. Dawson has more than once pointed out, bear a general resemblance to one of the Stromatoporids. A thinnish band of gneiss is intercalated in this limestone, which crops out in the wood near the road, but, as it happened, I did not see it.

The next mass occurs in the bed of the valley, and rather further up it, on a farm belonging to a Mr. Levine. It forms a small rugged knoll, which has been quarried. Here also the limestone varies a little in coarseness, and one of the more finely crystalline varieties contains grains of a nearly black mineral, which will be noticed presently. Eozoonal structure is not generally well developed here, but occasionally it may be seen. It exhibits the same relation to pyroxene and serpentine, the same nodular habit, and the same association with calcite containing granules of these minerals, as we have already described. Now and then, especially in the part where the pyroxene was most abundant, a little white mica occurred,

sometimes in plates as much as half an inch in diameter, and in one place the Eozoon was cut by a vein of about the same width filled with this mineral. In another case a micaceous band lay parallel with the surface of the Eozoon, separated from it by a zone of irregularly mixed calcite and serpentine (rather decomposed), about an inch in thickness. The pyroxene, in one part of the knoll, formed a mass, and contained an acicular tremolite, probably occurring as a vein (but this was not quite clear); and on the more northern flank was a rather coarsely crystalline rock, chiefly consisting of felspar; this probably was a vein-product, and may be connected with an intercalation of gneiss.[1]

The general strike of the apparent bedding suggests that this second mass is considerably higher in the group than the former one, but Sir J. W. Dawson expressed the opinion that the two were approximately on the same horizon, and that a flexure or thrusting towards the east had occurred. So far as one could judge from the outline of the country, the underlying mass of coarse gneisses, already described, was at about the same distance as before, so that this probably is the correct interpretation.

E. W.

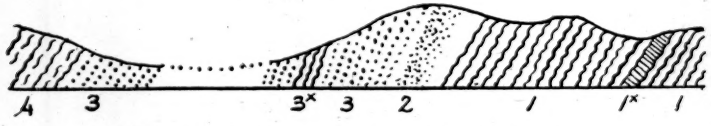


Fig. 2.—Probable succession at Côte St. Pierre.

1. Lower Gneiss.
1x. Quartzite.
2. Pyroxenite.
3. Crystalline Limestone (Eozoonal).
3x. Intercalated Gneiss.
4. Upper Gneiss.

The third mass is rather further up the valley, and also on the lower ground.[2] This is a rugged knoll of crystalline limestone, in which pits have been dug, one of them to obtain apatite. The hole was full of water, but I found some specimens. The mineral assumed two forms: (1) well-defined crystals of a greenish-grey colour, from a quarter to half an inch long, in calcite; (2) less regularly crystallized and of light cobalt-blue colour, with the same mineral and pyroxene. The apatite apparently occurred as a vein-product. A short distance from this was a good development of the Eozoonal structure, associated with pyroxene; the latter in masses of concretionary aspect, very irregular in outline and mode of occurrence. As before, the Eozoon formed an enclosing zone, up to a thickness of about four inches, and then passed rapidly into a crystalline limestone, containing granules of pyroxene or serpentine. In one part of this knoll the limestone is distinctly micaceous, and the following succession is exposed in ascending order, beginning

[1] This rock is a normal but perhaps rather fine-grained gneiss, inclined to be "platy" in structure. I do not remember that there was anything to suggest that it was intrusive; it seemed to pass rather rapidly into the limestone, but more as one sedimentary rock passes into another.

[2] The name of the owner was either Lavère or Laval; the farm was No. 10.

with the western side: (1) pyroxenite, about four feet; (2) patches of serpentine in calcite, about three feet; (3) crystalline micaceous limestone, about twelve feet; this is spotted with grains of pyroxene in the lowest part, and more distinctly banded with mica in the upper part.

One outcrop only of the upper gneiss, on the left bank of the valley, was examined. It agreed in general character with that seen on the road from Papineauville, being a distinctly foliated, rather fine-grained biotite gneiss, with alternating bands of more or less micaceous rock. Possibly there were also some indications of an intrusive granite, with but little mica.

The so-called Laurentian quartzite, under the microscope, does not exhibit the slightest trace of a fragmental origin. It consists of quartz, felspar (including microcline), mica (probably a bleached biotite), with a little, rather minute, chlorite, some grains of iron oxide (probably magnetite), and a few microlithic minerals, among them possibly zircon. It exhibits the structure which I have more than once described as very usual in primeval "gneisses," and only differs from them in being exceptionally rich in quartz. Into the microscopic details of the "Eozoonal" rocks I abstain from entering, as they have been so frequently described, and content myself with remarking that the peculiar structures, to which appeal has been made in the controversy, are exhibited by my specimens, in some cases very well. I will only add that the malacolite occasionally, the serpentine perhaps rather oftener, in the supposed "chambers" is stained by a black or brownish mineral, and that in one case [1] the darkish grains included in the calcite prove to be in some cases barely translucent, in others fairly so. The mineral then is of an umber-brown colour, which is doubly refracting, and occasionally becomes fibrous near the edge, but otherwise seems to have neither definite structure nor cleavage. I have not been able to satisfy myself as to its nature, but it bears some resemblance to one of the hydrocarbon group. Possibly, however, it is the loganite examined by Dr. T. Sterry Hunt. A like mineral occasionally forms a border to clear grains of serpentine. The calcite often has a "dusty" aspect, due apparently to the presence of a brown or black powder.

The Rev. J. F. Blake has expressed the opinion [2] that the granular magnesian mineral in these Eozoonal rocks is frequently olivine. It undoubtedly often resembles the latter mineral, and there is no *à priori* reason why this should not be present, especially such a variety (or species) as monticellite. Olivine, however, is commonly associated with igneous rocks, so that a little scepticism is justifiable, and some varieties of pyroxene (such as malacolite) appear to be readily converted into serpentine. The reasons also given by Mr. Blake in favour of his view appear to me inconclusive. Malacolite often exhibits high polarization tints and a similar texture to olivine, and is not seldom, when the grains are rather small, without cleavage. In my own specimens I find it impossible to distinguish, either by

[1] The specimen mentioned above as collected on Levine's Farm.

[2] Quoted by Messrs. Johnston-Lavis and Gregory, *loc. cit.*, p. 274.

texture, polarization tints, or general aspect, grains occurring in the cores or bands, which can be proved by cleavages and extinction angles to be monoclinic pyroxene (malacolite), from the separate uncleaved grains in the calcite or the fragment-like granules in the grains or masses of serpentine. Accordingly, while I admit the *possibility* of olivine being present, I think that this is not as yet proved by any valid evidence.

The observations described above indicate, I think, that the Eozoon often occurs in close relation, on the one hand with a fundamental mass of almost pure pyroxene or serpentine (the latter being, in many cases at least, an alteration product of the former); on the other hand, with a fairly large mass of crystalline limestone containing, sometimes in bands resembling stratification, more or less numerous grains of pyroxene or serpentine; the change in either direction being rather abrupt.

The concretionary habit, mentioned above, would accord either with a structure purely mineral, or with an organism which grew in irregular "cakes" or small reef-like masses like some Stromatoporids, but in the latter interpretation there are three difficulties: (1) We must assume that the organism has been infiltrated, very commonly, if not always, by a pyroxene (malacolite), and this, so far as we know, is not one of the silicates which usually discharges this function. (2) We must account for the grains of malacolite or serpentine in the external crystalline limestone. They might be regarded as detached casts of "chamberlets" of the organism; but this explanation presents some serious difficulties, which will be obvious to a petrologist, while the rock undoubtedly presents a close resemblance to an ordinary granular pyroxene-marble. (3) We must assume that as a rule the interior of the organism perished as the exterior grew, because the centre so commonly is a lump of practically pure silicate.

Whatever may be the origin of Eozoon, nothing which I saw in the field suggested the probability of the specimens being "blocks included in either a volcanic or plutonic mass." If the structure be not a fossil organism, it is at any rate as much a part of the whole rock as chert is of a limestone. There seems no reason for doubting that the valley is excavated in a thick mass of crystalline limestone included between two groups of gneiss, both of which exhibit a very rudely stratified arrangement, and differ in lithological characteristics. The larger masses of pyroxenite did not resemble any igneous rock known to me, but as to their origin I forbear at present to speculate. The felspathic vein did not resemble an igneous rock, nor did the intercalated gneiss. The latter might, of course, be an intrusive sill, modified by pressure; but of this I saw no evidence, and the adjacent limestone, if it has been crushed, has not retained any indication of this action. To the associations of the rock-masses I paid especial attention; because, before I visited Côte St. Pierre, it had occurred to me that possibly the Eozoonal limestone was a rock of later date folded or faulted into an older group. But everything that I saw led me to believe that the rocks formed a true sequence.

The gneisses, of course, may have had an igneous origin, but they certainly are not ordinary intrusive masses, and in any case I believe that the crystalline limestone belongs substantially to the same epoch. In other words there is nothing, so far as I can see, to differentiate the rock in which Eozoon occurs (except this peculiarity) from those other masses of crystalline limestone which are found elsewhere intercalated in gneisses and coarsely crystalline schists. How such rocks were produced is a question which is highly controversial, and upon which, as I have already expressed an opinion, I do not intend to enter. In this paper I have sought nothing more than to state certain facts of which account must be taken in framing any theory as to the origin of Eozoon. I will simply add that, to my mind, they offer a choice between two interpretations only; the structure is either a record of an organism, or a very peculiar and exceptional condition of a pyroxene-marble of Laurentian age, which is not a result of contact metamorphism in the ordinary sense of the term.

III.—Physiographical Studies in Lakeland.

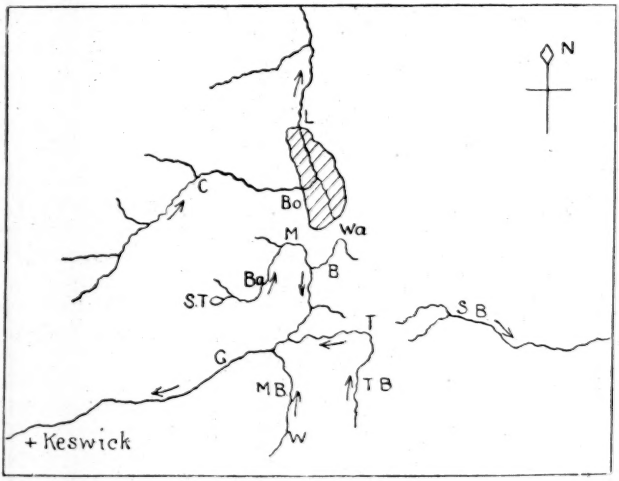
By J. E. Marr, M.A., F.R.S., Sec.G.S.

3. The Rivers Caldew and Glenderamackin.

A TRAVELLER alighting at Troutbeck station (T of Figure), at the summit level of the Keswick and Penrith Railway, finds himself standing at the north-east corner of a moorland plateau (Matterdale Common), having a mean height of over 1000 feet, and sloping gradually down to the River Glenderamackin (G), which bounds it on the north. The moorland is thickly covered with drift, and rock exposures are scarce, except here and there in the tributaries of the Glenderamackin, which run in a northerly direction from the Helvellyn Range, the principal being Troutbeck (T B) and Mosedale Beck (M B); (the latter is one of many of the same name in the district). That the stones in the drift were mainly brought from the Helvellyn Range is easily seen after a very slight examination; the boulders consist mainly of the more altered ashes and lavas derived from the Borrowdale series of the Helvellyn Range, with occasional boulders of the type of quartz-felsite dyke which penetrate the rocks of Helvellyn and its minor ridges (the best known being the familiar "Armboth and Helvellyn Dyke"); whilst the "Eycott" type of volcanic rock, occurring north of the main outcrop of Skiddaw Slates and having its nearest exposure within a mile of Troutbeck station, is entirely unrepresented. At the north-east corner of the moorland, close to Troutbeck station, a few boulders of mountain limestone indicate the point where the erratics from Helvellyn are beginning to be replaced by others brought from the eastward. The drifts of this moorland and of the region to the north have caused the interesting changes in the drainage of the area which it is the main object of this paper to describe.

(a) Shifting of the Drainage of the Troutbeck.

The Troutbeck (T B) rises on Matterdale Common, about three miles S.S.W. of Troutbeck station; it runs in a general N.N.E. direction until close to the station, when it turns sharply to the west, and passes through a rocky gorge of insignificant size, cut through the Skiddaw slates. In direct continuation with the upper part of the stream is a swampy depression, just south of the station and continued into Tarn Moss, from the eastern side of which (situated about $\frac{5}{8}$ of a mile E.N.E. of the station) a small beck (Swinescales Beck, S B) takes its rise, and eventually drains into the Eden, whilst the waters of Troutbeck find their way to the Derwent. The rise from the angle of the Troutbeck to Tarn Moss is almost inappreciable, and the watershed is not twenty feet above this angle where the Troutbeck turns sharply westward. The conformation of the ground shows clearly that the Troutbeck originally ran by way of Swinescales Beck into the Eden basin; and



Map of the Upper Waters of the Glenderamackin and Caldew.

Scale: 4 miles = 1 inch. Old lake marked by diagonal lines.

the part of the old valley now occupied by Tarn Moss and the ground immediately west of it having been filled by drift, this part of the course of the beck was blocked and the beck forced to turn westward, with the formation of a small lakelet which has now been filled up, but which must have existed recently as indicated by the name applied to the moss. It is here that the drift gives indications of the mingling of boulders brought from the east and south respectively, pointing to the accumulation of a specially thick deposit at the meeting of the Helvellyn and Eden Valley ice-lobes.[1]

[1] The extension of the Eden Valley ice to considerable heights on the west side of Edenside is not discussed here, but see Physiographical Studies, No. 2, "Swindale," Geol. Mag., Dec. IV, Vol. I (1894), p. 539.

(*b*) *The Upper Waters of the Glenderamackin and Caldew.*

The Glenderamackin (G) rises on the eastern face of Saddleback, one of its feeders issuing from Scales Tarn (S T), to be referred to later. It flows through Bannerdale (Ba) to Mungrisdale (M), a village lying four miles north-east of Scales Tarn in a direct line, though the distance is greater along the course of the winding stream. Here it comes out of the comparatively narrow valley of Bannerdale into a broad, nearly flat-bottomed valley, extending in a general north-and-south direction from the junction of the Glenderamackin and Troutbeck streams to the eastern side of Carrock Fell. On reaching this wide valley, the Glenderamackin stream turns sharply south, flows in that direction for two miles, and then turns towards the west and flows past Keswick (as the Greta), to join the Derwent.

After walking from Mungrisdale in a northerly direction for one mile, and noticing an apparently flat bottom to the wide valley above mentioned, extending from Barrow Beck (B) for a distance of three miles to Linewath (L), one is surprised to find the Caldew (C) at Bowscale (Bo) issuing from a narrow valley nearly parallel to that of the upper part of the Glenderamackin, and on reaching the wide valley turning *northwards* to fall eventually into the Eden at Carlisle, instead of southwards to join the Glenderamackin.

It is very apparent that at one time this wide valley was occupied by one river, and that the upper waters of the Caldew were afterwards deflected into the drainage area of the Eden, or the upper waters of the Glenderamackin were turned into the Derwent from the Eden drainage area. It is not a difficult task to discover which of these occurred.

Barrow Beck (B) cuts through drift containing abundant boulders from the Helvellyn Range (I readily found one of a Helvellyn quartz-felsite), so that at one time the Helvellyn ice extended as far as Barrow Beck; at this time the valley northwards seems to have been free of ice, for the moraine of the Bannerdale glacier descending from Saddleback is deposited at the mouth of Bannerdale (the village of Mungrisdale is situated on it, and the Glenderamackin has cut through it, south of the village, showing a series of river terraces at successive levels), and it does not extend across the main north-and-south valley. If the waters of the Caldew originally ran south, they would be blocked by the terminal moraine of the Helvellyn ice-lobe, and ponded back giving rise to a lake. That such a lake existed is indicated by the alluvial flat extending for three miles from White Moss just north of Barrow Beck to Linewath Farm. The position of this lake is indicated by the diagonally shaded part of the Figure. The terminal moraine of the Helvellyn ice-lobe is only a few feet above the alluvial flat, and now forms the watershed (Wa) between the Caldew and Glenderamackin. The old course of the Caldew is indicated to the south of this watershed by the lower part of Barrow Beck, and to the north by a nameless stream (shown traversing the southern part of what was once the lake).

At the northern end of the old lake, the Caldew cuts through a narrow gorge hollowed out of the Eycott volcanic rocks to a depth of about twenty feet. *The top of this gorge is somewhat lower than the top of the drift bar at the south end of the old lake.*

It seems clear that in pre-Glacial times a low watershed, between what are now the upper waters of the Caldew and the present lower (and principal) part of the river, existed at Linewath, and that the present upper waters of the Caldew then drained into the Glenderamackin; that during the Glacial period the terminal moraine of the Helvellyn ice-lobe blocked the present upper part of the Caldew, separating it from the Glenderamackin and forming the lake, and that this lake has been destroyed, partly by silting up and giving rise to Mosedale,[1] Bowscale, and White Mosses on its site, and partly by the cutting down of the stream at the outlet of the lake, forming the little gorge at Linewath. The diversion of the river would add an additional ten miles to the length of the Caldew.

(*c*) *Minor Moraines in the Glenderamackin Drainage Area.*

At the south end of Bannerdale Crags, and almost half-a-mile south-east of Bannerdale lead mine, a small crescentic moraine occurs at the bottom of a "comb." A stream section shows the moraine-stuff to consist of gravelly clay, with numerous subangular striated blocks of Skiddaw Slate. A similar moraine is seen at the foot of Scales Tarn (S T). The stream from the tarn has cut a section in a very stiff clay with many scratched boulders of Skiddaw Slate. It is clear that this moraine has caused the formation of Scales Tarn, which is neither a rock basin nor due to blocking by snow-slope screes. At the time of my visit this year, on April 7th, the tarn was still frozen over.

A very pretty crescentic moraine noticed by Clifton Ward occurs beneath Wolf Crags (W) at the north end of the Helvellyn Range. It is known as Barberry Rigg, and its two ends are a little more than half-a-mile apart in a straight line.[2] In places it is about 40 feet high, and must at one time have given rise to a tarn, now occupied by a peat moss. A gorge about 30 feet deep, cut through it, shows that it is a true moraine, in which a few scratched stones occur amongst the subangular blocks which fill it, though, owing to the nature of the rocks, one cannot expect many scratches to be preserved. Before the formation of the gorge the tarn must have been over 20 feet deep, and probably considerably deeper, as a good deal of deposit has taken place in it. Mr. Clifton Ward alludes to it in the Geological Survey Memoir "On the Northern part of the English Lake District," pp. 90 and 98. He remarks, on p. 98, that "the glaciers crept down to the level of the sea, sometimes forming moraines just at the sea-margin, as was the case beneath Wolf Crag, Matterdale Common, when the land stood 1,400 feet below its present level." He gives no reasons for the view that this moraine was formed at the sea-level, and though I devoted a considerable

[1] Yet another Mosedale.

[2] See 6-inch map, geologically coloured.

amount of time to examining this special point, I could find none. Be this as it may, it is the prettiest exhibition of the terminal moraine of a small comb-glacier which I have seen in this or any other district, and it is well worth taking the somewhat uninteresting walk which is necessary to reach it.

IV.—The Volcano of Tardree, County Antrim.

By Grenville A. J. Cole, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland.

I PROPOSE in the autumn of the present year to lay certain detailed observations on the rhyolites of County Antrim before the Royal Dublin Society; but meanwhile it may be of interest to give some account of the mode of occurrence of these rocks in their most central locality, the neighbourhood of Carnearney and Tardree.

Mr. A. McHenry, F.G.S., some four years ago, while preparing a series of specimens for exhibition in the Museum of Science and Art, Dublin, called my attention to some of the little known varieties of rhyolite from Sandy Braes; and I subsequently visited Hungary, in order to become familiar with the typical highly silicated lava-flows studied by Beudant, Von Richthofen, Judd, Szabó, and others. Since then, in various visits to County Antrim, I became impressed with the unique character of the Tardree volcano, as far as our islands are concerned, and with the comparative neglect in which its beautiful products have been suffered to remain.

The general characters of the district have been described in the Memoirs of the Geological Survey of Ireland, and I shall hope to discuss the question of the geological horizon of the rhyolites when dealing with a wider area. It may be sufficient to remark here that evidence as to the true relations of the rhyolites and the basalts around Tardree is sadly wanting in the field. This has been fairly recognised by those who have ventured to draw sections across the district; and neither the intrusion of the Tardree mass as a dome amid the older basalts, nor its burial by the later basalts, can be regarded as absolutely proved.

For some reason or other, the rhyolites of County Antrim have been almost constantly styled "trachytes," although that name has, for some thirty years, been restricted to another class of lavas. Von Lasaulx's[1] well-known examination of the Tardree rock is to some extent responsible for this; but he styled it a "quarz-sanidintrachyt" in his descriptive paper, and a "quarzsanidinrhyolit" in his more popular volume.[2]

In the present state of nomenclature, the term "trachyte" can no longer be used in connection with the Tardree volcano, nor, as far as I am aware, with any post-Cretaceous rock in County Antrim.

The main exposures of rhyolite in the Tardree area, as we go from south to north, are met with as follows:—a cutting in a farm-road

[1] "Petrographische Skizzen aus Irland," Tschermak's Min. u. Petr. Mittheilungen, Bd. i (1878), p. 418.

[2] "Aus Irland" (1878), p. 167.

which descends northward from Scolboa Hill; jutting rocks flanking the notch which runs east and west across Carnearney Hill; two small quarries in the north-west angle of the cross-roads before we reach Tardree Cottage; the well-known quarries of Tardree Mountain itself; sections on the steep ascent to Sandy Braes, beyond the road from Parkgate to Kells; and a number of small excavations on the high moor of Sandy Braes.

The Tardree mass, as now denuded, forms a beautifully regular dome, and presents all the characters of a volcanic core. Its division by vertical joint-planes reminds one of the structure of the phonolite necks of northern Bohemia; while its outline recalls the Grand Sarcouy of Auvergne. The compactness and uniform character of the rock, the abundance of porphyritic crystals, and the absence of fluidal structure, all point to its having formed a continuous mass, probably in the centre of the volcano.

But these characters are rapidly lost as we proceed north or south from Tardree Mountain. The Tardree type of rhyolite, grey, or pale pink, or yellow-brown, crops out here and there; but the larger exposures now show it to possess a distinctly laminated structure. Nothing can be well made out at the cross-roads south of Tardree Cottage, and the brilliant red staining of the rhyolites in the quarries at this point results from irregular alteration, and not from the association of lava-flows of different compositions. On the rise towards Carnearney the compact type is also seen; but in the notch south of the new plantation two kinds of rhyolite are visible. A small cliff faces the plantation, its upper part being formed of compact but fissile rhyolite. There is no obvious flow-structure to account for the parallel and gently dipping planes of division in this rock; but beneath it, the plane of junction being parallel to those of fissility in the upper rhyolites, lies a handsome spherulitic obsidian, preserving all its character as a grey glass, traversed by perlitic cracks. These rocks recall the cliff of Skleno, near Selmeczbánya, with its variety of compact and glassy lavas, poured out as flows one upon another.

The humble exposure at Scolboa merely shows pink, compact, and porphyritic rhyolite, somehow underlying a handsome olivine-basalt. Similarly, the dip of the rhyolites on the north end of Carnearney would bring them under the basalt-flows of the south end and of the summit of the hill. Sir A. Geikie[1] has stated that he knew of no case in which acid lavas of Cainozoic times reached the surface in our islands, save at the Scuir of Eigg; but his omission of the rocks of Sandy Braes from his account of the Cainozoic pitchstones[2] shows that the compact rhyolites of Tardree were the predominant type present to his mind. The exposure on Carnearney looks suspiciously like a section at the junction of two lava-flows, and there is nothing surprising in its occurrence on the south flank of the denuded volcano of Tardree.

[1] "The History of Volcanic Action during the Tertiary Period in the British Isles," Trans. Roy. Soc. Edin., vol. xxxv (1888), p. 145.

[2] *Ibid.*, p. 146.

But the northern side of that volcano shows a far more striking assemblage of rhyolites, among them being the exquisitely perlitic glass recently dealt with by Mr. W. W. Watts.[1] This is the "pitchstone porphyry" and "pearlstone porphyry" of Sandy Braes, noted by Berger,[2] Portlock,[3] and other older authors.

It is surprising how the spread of petrography on the Continent has sent us to Hungary or Lipari for our specimens of rhyolite, while the rich variety of material on Sandy Braes has been scarcely known to the collector.

Von Lasaulx was acquainted with the glassy type of the rhyolites of County Antrim merely from specimens that were shown to him in Dublin; and few of the eminent geologists who have visited the quarries of Tardree appear to have climbed thence to the plateau of Sandy Braes. This upland is traversed by a bold mountain-road, commanding superb views, and running from Doagh to Connor; and a steep lane rises up to it just east of the inn on the north side of Tardree Mountain. The name Sandy Braes does not occur on the 1-inch Ordnance Map, but is easily found upon the 6-inch sheet; it has a real meaning to the local farmers, who quarry the decomposing rhyolites for sand.

On the steep cross-road referred to, there is a little quarry, which is visible from the Tardree inn; the rock is a pink and well-banded rhyolite, its planes of flow being distinctly visible at a distance. Above this, the surface of the moorland is strewn with boulders, large and small, consisting of grey, black, and greenish obsidian, sometimes perlitic, rarely spherulitic, and always containing porphyritic quartz and felspars. This rock breaks up easily under the hammer, and its numerous joint-planes and its partial decomposition cause it to weather down into a yellowish sand. This is the material excavated for use on the paths of local demesnes, and it can be seen in the casual little diggings that are made from time to time. These diggings do not go farther down than the first hard rock, so that their walls show merely lumps of glassy rhyolite embedded in soft sand; but their floors consist of surfaces of decomposing glass, or of compacter and firmer rhyolite, like that of the quarry on the ascent. From the crest of this ascent, across the Doagh road, and away to Sandy Braes, the rock below the surface of the grass or heather is almost pure obsidian. It is probable that the flat dome-like summit forming the southern extension of the braes originated mainly in the surface of a single lava-flow, which was formerly connected with the central mass at Tardree Mountain.

Compact rhyolites occur as we push across to Sandy Braes, and serve to show how the crust of the obsidian, which is now mostly broken up into boulders, is in reality only two or three feet in thickness. At the east end of the braes there is a red compact

[1] "The Occurrence of Perlitic Cracks in Quartz," Q.J.G.S. vol. l (1894), p. 368.
[2] "On the Geological Features of the North-eastern Counties of Ireland," Trans. Geol. Soc., ser. i, vol. iii (1816), p. 190.
[3] "Report on the Geology of Londonderry, etc.," 1843, p. 212.

rhyolite, with banded structure, comparable in type to the "mill-stone-porphyry" of Hliník in Hungary, but of somewhat coarser character. At the west end, on the airy summit of the moor, rhyolite of the Tardree type crops out; and in between, near a hollow of the road, its glassy representatives abound. The banded and fluidal pitchstones of Skleno are here beautifully repeated; and dull-brown spherulitic aggregations also occur, their cracks and hollows being filled, as in Hungary, with chalcedony and common opal.[1] No continuous mass of glass is visible, and in one pit the obsidian boulders resemble blocks that became included in a more crystalline flow, the latter having now decomposed to form a sand. A resisting layer of pale pink rhyolite occurs a few yards farther north, and no doubt extends down into the hill; and above it, and in contact with it, is an agglomerate of glassy and dark hemi-crystalline fragments of rhyolite, embedded in a firm yellowish ground. This can hardly be anything but a true tuff; and many of the sands containing obsidian boulders in this district may have been formed by the breaking up of similar layers. The exposure is a small one, and this interesting relic may disappear under a few weeks' quarrying. It became revealed, however, between two successive visits made in 1894 and 1895; and at any time further evidence of explosive action may be met with in the surface-diggings of Sandy Braes.

Nothing short of deeper trenches or more serious quarrying can show us the real wealth of the material on the heights north of Tardree Mountain; but I trust I have said enough to sustain my main contention. I regard the Tardree dome as the neck formed by the upwelling of a viscid rhyolite, which occasionally flowed out over the Chalk, and perhaps over some of the earlier basalts, round about it. A considerable volcano was in time built up, its flanks formed of true lava-flows and even of tuffs; glassy crusts were developed freely by the rapid cooling of these flows, and various types of obsidian were spread out over some four square miles. The lava-flows have been much reduced by denudation, and are now obviously crumbling away on the high moor of Sandy Braes; but both here and under the later basalt of Carnearney we have evidence of the former complexity and variety of the rhyolitic volcano of Tardree.

V.—Preliminary Notes on the late Connection and Separation of the Pacific Ocean and Gulf of Mexico.

By Prof. J. W. Spencer, M.A., Ph.D., B.A.Sc., F.G.S.

HAVING recently returned from another season's work in the West Indies and Mexico, where I was collecting additional data bearing upon the stupendous changes of level of land and sea which have lately affected the American continent, I find the review of the "Reconstruction of the Antillean Continent" by Mr. Jukes-Browne in the Geological Magazine, April 1895, p. 173, a few points of which may be further explained at the same time

[1] Compare Berger, *op. cit.*, p. 190.

that I furnish some advance notes concerning recently observed phenomena which greatly strengthen the theory of stupendous changes of level in the Pleistocene period. Many months must elapse before I shall be able to complete the studies for publication, so that my papers on Cuba, Jamaica, and Mexico shall be published.

It may be said that the date of the recent continental elevations are based on the extent of the erosion of the Miocene and later deposits. In the south-eastern states but little of the Upper Miocene (American equivalent) has been preserved from erosion. In Cuba and Jamaica the Miocene limestones have suffered enormous degradation, so that probably only the lower strata remain, yet these are of immense thickness, although they are often completely incised by great valleys. The same phenomena hold good for regions south of the Mexican Gulf. The determination of the ages of the beds is based upon palæontological as well as stratigraphical and lithological evidence. The lists of fossils will be submitted in forthcoming papers. In the southern states these deposits are not disturbed to any great extent, but beyond they are everywhere upturned and often occur at high angles. Overlying and occupying portions of the great valleys, there are the widespread loams and gravels of the Lafayette formation of the southern states, which extend also over the coastal plains of Mexico. On the islands, apparently, the same formation occurs, but in part represented by marls, with some included gravel (the Matanzas formation), and these contain fossils of mostly modern species. With the oscillations of land and sea, the perfect synchronism between the eastern and western beds is not claimed, but only the general equivalency, as the continental movements passed from east to west and back again. These Lafayette and Matanzas beds have a remarkably wide distribution, and present a wonderful degree of uniformity, so that the geology of the vast region is greatly simplified. These formations have been provisionally regarded as belonging to about the close of the Pliocene period, and whether a little earlier or a little later is of no material difference. It is the sequence of events which forms the importance of the study, for the palæontological boundaries are somewhat ill defined at present. The surfaces of these Lafayette and Matanzas accumulations have been greatly denuded, so that in many places they are found only in fragments, which have nevertheless been most important in the investigations concerning the "Reconstruction of the Antillean Continent." In these valleys, again, we find later mid-Pleistocene formations which have been traced to the regions of northern drift accumulations. The great continental elevation reached its culmination in the post-Lafayette or early Pleistocene epoch, so far as the eastern part of America is concerned. But at that time I have recently found upon the Tehuantepec isthmus, where the drainage of the eastern plateau was hypothesized to have passed to the Pacific Ocean, that the country was so low as not to permit the formation of deep valleys such as were being formed to the east, and are now drowned beneath the sea or buried along the Atlantic or Gulf coast.

The edges of the Mexican table-lands (a term more correct than elevated valleys) show the counterparts of the submerged valleys to the east—an analogy not found in the valleys of the eastern part of the continent—for the now unsubmerged portions of the continent were too far from their margins to have been incised by the growing *cañons* of the period of great elevation. Yet these Mexican examples represent a shorter duration of time than the drowned Antillean valleys.

In Mexico youthful terraces occur to an elevation of 6,500 feet above the sea, and base planes of erosion upon the margins of the Mesas to an elevation of 8,000 feet. With this enormous elevation the terrace materials in the older valleys have not been removed by denudation except in part, and the youthful *cañons* have not yet reached far into the plains. Thus it appears that Mexico has risen to this great altitude in very recent times, and, when we correlate the geological foundations, it would appear that Mexico and Central America have risen to almost as great an elevation as the late altitude of the Antilles and eastern part of America, while the floor of the Mexican Gulf has been sinking.

Across the floor of the divide between the Atlantic and the Pacific, in the Isthmus of Tehuantepec, there were recent shallow straits, succeeded by natural canals covered with level gravel floors continuous with the terraces on the Atlantic side. The importance lies in the admittance to the Gulf of the sparsely-distributed Pacific littoral types of molluscs. But the gravel floors of the channels over the divides form a most important analogy. Such floors over the watersheds of the Great Lakes of North America have been regarded by some glacialists as evidence *per se* of glacial dams confining the waters of the lake basins at high altitudes. Against this view there are many considerations, but now that the same phenomenon is found within a few degrees of the Equator, and at low elevations, the value of this test for glacial dams disappears.

While no phenomena observed in the Antillean region have weakened the hypothesis of the great changes of land and sea in recent times, yet there is much detailed evidence supporting the theories set forth in the "Reconstruction of the Antillean Continent," of which the points mentioned have a most important bearing, as filling important gaps in the chain of evidence, concerning which we had not the direct observations before the present time.

VI.—Second Note on the Expansion Theory of Mountain Evolution.

By Charles Davison, M.A., F.G.S.,
Mathematical Master at King Edward's High School, Birmingham.

In a note published four years ago,[1] I pointed out a fundamental objection to the principle of the expansion theory. That objection has been clearly expressed as follows by Prof. Leconte,[2] who, like myself, considers it fatal to the theory: "Sedimentation

[1] Geol. Mag., Vol. VIII, 1891, p. 210.
[2] Journ. of Geol., vol. i, 1893, pp. 570–571.

cannot, of course, increase the sum of heat in the earth. Therefore the increased heat of the sediments by rise of isogeotherms, *must be taken from somewhere else.* Is it taken from below? Then the radius [or rather crust] below must contract as much as the sediments expand, and therefore there will be no elevation. Is it taken from the containing sides? Then the sides must lose as much as the sediments gain, and therefore must contract and make room for the lateral expansion, and therefore there would be no folding and no elevation."

It appeared to me possible, however, that the sediment, owing to a less conductivity, might check the transmission of heat through it more than the surrounding crust, and that there might consequently be some, though certainly a small, relative elevation due to the cause invoked. This I now believe to be an error, for I was not then aware how greatly the presence of water can increase the conductivity of sand and rocks. That it does so is evident from the experiments of Professors Herschel and Lebour.[1] They find, for instance, that the conductivity of quartzose sand is ·00105 when dry and ·00820 when wet, that of New Red Sandstone is increased from ·00250 when dry to ·00600 when wet, and that of clay from ·00250 to ·00350. Now, considering that the average conductivity of crystalline and volcanic rocks is ·00519, of schistose and slate rocks ·00531, of different kinds of sandstone ·00734 and ·00323, of limestones ·00561, and of argillaceous strata ·00242, it is evident that I was wrong in supposing that the conductivity of *saturated* sediment might be small enough for it to act as a relative check on the passage of heat from the interior. I conclude, therefore, that the force of the objection, great as it was before, is increased by this additional consideration.

VII.—On the Formation at Low Temperatures of certain Fluorides, Silicates, Oxides, etc., in the Pipernoid Tuff of the Campania.

By Prof. H. J. Johnston-Lavis, M.D., F.G.S., etc.

With a Note on the Determination of some of the Species.

By Prof. Pasquale Franco, M.D., etc.

WHEN such minerals as mica, pyroxene, nepheline, fluorite, and hematite are mentioned to us, we can hardly avoid associating their genesis with very high temperatures, and if amphibole be added we are equally bound to imagine also the existence of high pressure. So deeply rooted is this, I might almost say, superstition that few petrographers, when they find such minerals lining the fissures or cavities in rocks, fail to immediately conclude that great heat, and sometimes pressure, is indicated by such an occurrence. No doubt that in the vast majority of cases they would be right, yet I hope to show in these notes that such minerals have occasionally been produced under little or no pressure

[1] Brit. Assoc. Rep. 1881, pp. 130–135; quoted by Prestwich, "Controverted Questions of Geology," pp. 240–241.

at a temperature so low as to be insufficient to carbonize or even discolour the organic matter of bone, that is at a temperature considerably below that of an ordinary baking oven.

A. Scacchi was the first to draw attention to certain enclosures in the grey tuffs of the Campania, which I have shown to be the representatives of that enigmatical rock the *piperno* of Pianura, and to hold chronologically and stratigraphically the same relative position. To denote the peculiar structure due to the enclosures of different texture of these as well as rocks from different parts of the world, I have proposed the adjective pipernoid, and references to this clastic volcanic rock in several of my papers is denoted as pipernoid tuff.

A. Scacchi supposed this tuff to be the result of mud streams that issued from a wreath of volcanic vents scattered all along the edge of the Campanian plain, where limited by the limestone hills; and the metamorphosed limestone enclosures he considered as true ejected blocks, or, as Prof. Lacroix calls them, *enclaves*. I have been able to refute these views, for the following reasons, as concisely summarized below [1]:—

(1) The pipernoid tuff is a typical andesitic or trachytic scoria, pumice, and dust deposit, and bears no relationship whatever to the clays of mud volcanoes.

(2) To have produced such deposit of it, dozens of months would have been required, not only where A. Scacchi locates them but over hundreds of square miles, and often at the tops and shelves of calcareous mountains, unless we were to admit the mud to have flowed uphill.

(3) The metamorphosed limestone fragments only occur in the pipernoid tuff where this forms a talus against a limestone hill, and are distributed in the tuff in curved wedge-shaped bands just as any fragments are arranged in a talus by the law of angles of repose.

(4) The greater thickness of the tuffs at the foot of the limestone hills is simply due to the talus formed at their feet by the washing down of the mantle of fragmentary material that covered them after their fall from the air at the time of the eruption.

(5) That the same arguments as apply to the number of volcanic vents also apply to the existence of fluoriferous fumaroles or springs, as suggested by A. Scacchi.

It is evident, therefore, that in such a tuff, after its journey through the air, its fall on the surface of the country, and its subsequent transport to lower levels by water, that no heat above that of the surrounding atmosphere could remain, of what existed at the volcano from which the ejecta had been derived, to act upon any inclusions in such a tuff. If any doubts on this point existed, the uncarbonized, unroasted bones included in the tuff would finally dispose of them.

The bone in question I easily recognized as the upper part of a tibia, probably of *Cervus*, and this diagnosis was subsequently

[1] See H. J. Johnston-Lavis: British Association Reports for 1888–89–90–92, and Notes on Pipernoid Structure of Igneous Rocks, "Natural Science," vol. iii, No. 19, September, 1893, pp. 218–221.

confirmed by Professors Bassani and Trinchese. The bone is not entire, but no doubt was so in the tuff, part having been broken off in quarrying operations. It occupied a somewhat larger space than requisite in its matrix, as if part of the flesh were still adherent to it at the time of its burial, or, more likely, the effervescence set up by the acid contained in the dust that enveloped it attacked it and produced sufficient gas to distend the cavity around it. That such was more probably the case is shown by enclosures of limestone which have likewise effervesced, and so now occupy cavities of larger volume than that of the original fragment of limestone. The bone in question is fissured and cracked as if it had shrunk, due no doubt to the removal of some of its organic or earthy constituents, or the chemical replacement of some of them by others of less volume. This bone is covered by a coffee-brown crust up to a tenth or more of a millimetre thick, and consists of the following minerals, according to A. Scacchi and Prof. P. Franco, of augite, hornblende, and biaxial mica, and I have since detected on a small detached fragment of another bone some imperfect yellowish hexagonal prisms quite identical with those on the limestone enclosures, which prisms, though very impure, give the microchemical reactions of nepheline. This second bone was found only a few yards from the tibia, and therefore could not have been exposed to any important difference of temperature. It is true that it contains no organic matter, but that may be due to its being an old weathered bone before its envelopment in the tuff. The same argument applies, though with less force, to the ovine vertebræ from the neighbouring quarry of Fossa Lupara, which contains crystals of hematite in the cavities. With such spongy bones the organic matter disappears much more quickly than in one of the densest parts of the skeleton, such as the main leg bone.

To return to the tibia—the layer of silicates crusts over both the outside surface and that of the marrow cavity and, what is important, the sides of the fissures, which shows that the deposition of such minerals must have been some time later than the fissuring. This fissuring was posterior to the envelopment of the bone in the tuff, for so fragile is it in consequence of their formation that nothing less than a miracle would have preserved it entire.

The composition of this bone is very instructive. A. Scacchi found that it contained:—

Calcium orthophosphate	88·32
Calcium fluoride	6·20
Organic matter	5·48

From the researches of Heintz, Recklinghausen, Zalesky, Hoppe-Seyler, and others, the following is the mineral constitution of bone:—

Calcium phosphate	83·889
Calcium carbonate	13·032
Calcium as fluorides, chlorides, etc.	0·352
Fluorine	0·229
Chlorine	0·183

Different bones of the same animal vary in composition, as do the

same bones of different animals. The tibia is one of the densest bones of the body, and the part analysed by Scacchi was the shaft portion and therefore the densest part of that bone. Still, it will be seen that the calcic phosphate is very high—over 93 per cent. of the inorganic constituents: whether this be due to a conversion of some of the original calcic carbonate into phosphate is not easy to say. What, however, is strikingly evident is the conversion of a large part of the calcic carbonate into calcic fluoride so as to constitute over 6 per cent. Fluorine does occur in bones, but in very minute proportions. If we consider the other 6 or 7 per cent. of carbonate to have become phosphate we could then explain the high proportion of this latter compound in Scacchi's analysis.

The organic matter in the Faiano specimen amounts to 5·48 per cent., and Scacchi, in making his analysis, was struck by the fact that in heating the creamy-white bone it blackened and gave off an odour of burnt horn. He did not appreciate the valuable bearing of such a fact on mineral genesis, *for it proves incontrovertibly that the minerals associated with this bone could not have been produced at a temperature sufficiently high to even discolour it, much less to carbonize its organic matter.* Not only this, it likewise shows that the other minerals formed at the expense of the limestone fragments in its immediate neighbourhood must likewise have taken place at a low temperature.

Dried bones afford about 11·40 per cent. of nitrogeneous organic matter and 15·75 per cent. of fat. If we suppose all the fat to have disappeared we even then find the quantity of ossein far below the normal. This could hardly be more than we should expect—it is astonishing rather that such a quantity of organic matter has remained, and its existence points to no very great antiquity of the tuff, which certainly is anterior to the last 660 metres in height of Monte Somma, previous to its great prehistoric truncation, which truncation must be anterior to the last 3000 years. The vertebræ obtained by Scacchi from the neighbouring quarry had lost their organic matter—a state of things to be expected in such porous spongy bones, but they likewise had all their calcic carbonate converted into fluorite.

In the Faiano and Fossa Lupara quarries, numbers of fragments of limestone have been enveloped in the tuff and have undergone most marked changes. All the blocks up to the size of a cocoa-nut have been entirely converted into a mass of beautiful brown mica crystals, which form a shell having the original shape of the enclosure. Within this shell is a hollow space with elegant groups of hyaline globules or radiating bunches of fluorite associated with delicate fibres and needles of nocerite. Besides the mica are crystals of augite, hornblende, and a mineral of the nepheline group, but very impure from enclosures.

Where large blocks of limestone occur, they are in some cases covered with a solidified froth of fluorite, or their surfaces are converted for the depth of several centimetres into mixture of the silicates and fluorides above mentioned, whilst farther in arragonite

has been formed at the expense of the calcite of the limestone. This arragonite would seem to indicate some slight warmth to have existed for its formation, but whether of original volcanic heat of the tuff itself or dependent upon heat liberated in the chemical decomposition going on, it is not easy to determine.

The quantity of fluorine must have been very considerable, because the amount of fluorides formed constitute the major part of the products of metamorphism.

The whole of these changes, therefore, was due to some fluorine compound in the original volcanic material, which A. Scacchi shows would most likely be hydro-fluosilicic acid.

Fluorine and minute quantities of fluorides have often been found in volcanic emanations, but the quantity that must have accompanied the dust and scoria of the eruptions to which we owe the pipernoid tuff was exceptionally great. Where these and other constituents of the tuff have been reacted upon slowly with calcite in any form, either organic or inorganic, certain minerals have resulted which are supposed to require very high temperatures, and in some cases high pressures, for their genesis. Of course the mode of formation of hornblende under such conditions is of interest in considering the case where this mineral occupies vesicles or fissures in a cooling lava, but does not in any way militate against the fact of its individualization from a vitreous base being still regarded as indicative of high temperature and pressure.[1]

Finally this is one more confirmation of the fact of the great importance we must attach to fluorine as a mineralizing agent.

I must thank my friend and colleague Prof. P. Franco for kindly clearing up by careful measurements some doubts about the minerals epigenized upon the bone.

Minerals Formed on the Fossil Bones of the Tufa of Faiano near Nocera.

It is a known fact that in the volcanic tuffs of the Campania bones of ruminants occur with minerals superposed on their surfaces and in their cavities. A. Scacchi[2] described a tibia found by and contained in the valuable collection of Prof. Johnston-Lavis as well as a vertebra in the collection of the University Museum in Naples. On these bones he recognized hematite and amphibole. A. Scacchi adds that there are minute brownish-yellow crystals of indeterminable form, but which, under the microscope, appeared by the distribution of some of the faces to be rectangular; he likewise mentions some thin white crystals, that are not mica.

Dr. Johnston-Lavis has courteously allowed me to examine the specimen described by Scacchi. I have been able to recognize on it a pyroxene (augite), mica, and I have determined the form of the amphibole crystals, which was not done by Scacchi.

[1] H. J. Johnston-Lavis, "Relationship of the Structure of Igneous Rocks to the Conditions of their Formation," Scientific Proc. Royal Dublin Soc., vol. v, n.s., pp. 112–156; also Q.J.G.S., vol. xli, pp. 103–106.

[2] A. Scacchi, "Sulle ossa fossile trovate nel tufo dei vulcani fluoriferi della Campania," Atti dell' Acc. delle Scienze di Napoli 1888, p. 6; and also "La Regione vulcanica fluorifera della Campania," Mem. del R. Comitato Geoligico Ital., 2nd ediz., Firenze, 1890, p. 34.

Amphibole (*Hornblende*).

Observed forms (110), (010), (100), (001), ($\bar{1}11$). The faces are very small (0·2 mm.) and feebly reflecting; the observed average inclinations differ by about half a degree from the calculated inclinations. The crystals have a black colour, resinous lustre, and are opaque.

Pyroxene (*Augite*).

Observed forms (110), (010), (100), ($\bar{1}11$).[1]

Average of observed angles.	Number of observations.	Calculated angles.
110 ∧ 010 43° 10′	3	43° 35′
110 ∧ 100 46° 45′	3	46° 25′
$\bar{1}11$ ∧ 010 60° 0′	1	60° 24′

The crystals elongated in the axis C are extremely small, but have brilliant faces, vary in colour from greenish to brownish-yellow, vitreous lustre, are translucent, and exhibit marked chromatic polarization. On the bigger crystals are implanted obliquely smaller ones, in both of which when digested in H Cl. no alteration could be observed, except slight discolouration.

Mica occurs in hexagonal laminæ, very small in size, and very thin. Very rarely with a strong lens can the faces of the zone (001) be distinguished. The colour is brownish, more or less dull, the lustre between adamantine and pearly, and the laminæ are translucent. In some cases the mica is altered, opaque, and has a submetallic lustre. Under the microscope the more coloured laminæ show distinct dichroism, and are distinctly biaxial, normal to the base; but on account of their extreme thinness they do not give in convergent polarized light very distinct curves. In a large proportion of the crystals phenomena of reabsorption with the production of ferrite have taken place, and some are completely transformed into a mass of this mineral.

VIII.—Note on a Contact-Rock from Shap.

By W. Maynard Hutchings, F.G.S.

ONE of the contact-rocks from Shap, which I collected a few years ago, has always presented some points of special interest; and in view of a recent careful re-examination of it, microscopical and chemical, I think a few remarks upon it may not be out of place.

It occurs on the slope of Wasdale Pike, high up above the farmhouse of Wasdale Head, and appears to be, in the main, the same as the rocks which are described by Harker and Marr in their paper on the district (Quart. Journ. Geol. Soc., vol. xlvii, 1891), and of which they say (p. 308) that they "have a very distinct lamination, and give in the field a suggestion of crystalline schists, or even of gneisses." This description applies fully to the specimens collected by me from a point about 15 feet from the actual contact.

I first examined the rock a year before I had the pleasure and advantage of going over the ground with Mr. Marr, when I had no

[1] The formula of the faces are those of Miller, and the calculated angles are those in Dana's Mineralogy.

knowledge whatever of the district round the granite; and from its character, macroscopic and microscopic, I set it down as an altered sedimentary, probably a slate, with little or no quartz. Mr. Marr, however, informed me that it is an altered ash, and it was subsequently so described by him and Mr. Harker.

It is so highly altered and completely regenerated that not a particle of original material is left, and so far as *microscopic examination* went, it was mainly on the strength of the presence of certain new minerals, usually connected with altered sedimentary rocks, that the erroneous inference was drawn which was corrected by Mr. Marr's minute knowledge of the field-relationships of the beds.

The most striking point in the mineralogical constitution of the rock is that it contains a considerable amount of both sillimanite and andalusite, the specimens in question being the only ones collected, either by Harker and Marr or by myself, which show the presence of either of these minerals in an altered rock at Shap.

There is nothing of note about the abundant andalusite, but the sillimanite, in addition to bundles of very slender needles and fibres, forms some rather unusually fine prismatic crystals.

As has been previously pointed out, this is the only recorded instance of the formation of sillimanite and andalusite in altered volcanic material, and it is so far deserving of notice as being an additional proof that the *chemical* composition of the rocks invaded, and not their mode of origin or their *mineralogical* constitution, influences the nature of the new minerals formed under the effects of contact-action.

Other minerals present are magnetite, apatite, a good deal of perfectly colourless garnet, in rounded and irregular grains without any crystal faces, a little white mica, and a still smaller amount of biotite, both of the latter irregularly diffused in small patches.

By far the main portion of the rock is made up of felspar, in a mosaic of very varying degrees of development as to size of grain and distinctness of individuals. It is beyond all question completely a *new* formation, and among all the slides of contact-rocks which I have studied I have never seen so complete and striking a development of the mineral, due entirely to contact-action, as in this case.

A large part of it is very fine-grained and acts as a sort of groundmass. In this occur many larger individual grains of the felspar, easily identified as such, and several patches in each slide made up of a mosaic of interlocking grains of strikingly larger dimensions.

Quartz is either absent or very sparingly represented. If present, it is only in the most fine-grained part of the mosaics, as it cannot be identified in the coarser parts.

Many of the felspar-grains, especially in very thin slides, show a very fine lamination or striation, best seen in polarized light. In smaller grains it makes more the effect of the minute striation which has been recognized as frequently characterizing contact-felspar, but in the larger grains of the rock it is often developed in a very much higher degree, there being also various intermediate stages. Taking the larger grains only, this lamellation in polarized light may be seen

passing down to a degree of fineness which is only just capable of definition with moderately high powers and good illumination, and there are, again, grains in which it is not seen at all. The same is true of the grains of more moderate size, and among these some few of them which are not striated are single twins, extinguishing quite parallel and safely referable to orthoclase.

Among the larger grains a good number have cleavage distinctly developed, and by patiently searching among these, cases may be found in which there is emergence of a positive bisectrix nearly central, with an extinction-angle, measured against the well-marked cleavage, of 10° to 12°—very often 12° exactly.

These characteristics—the minute lamellation passing down into such a degree of fineness that it cannot any longer be made out, and the extinction-angle of about 12° on *m* flakes—seem to indicate that we are dealing with a felspar similar in nature to that which occurs in pegmatitic veins at Frederiksvärn, in connection with the so-called soda-orthoclase, with which it appears to be intimately related by passages from one to the other, with a similar chemical composition in both cases.

Brögger has concluded that this lamellar felspar at Frederiksvärn is a microscopic intergrowth of orthoclase and albite—a microperthite—passing down into a sub-microscopic degree of intergrowth which cannot be resolved by the microscope, and which he designates as cryptoperthite.

The analysis of the felspar from Frederiksvärn shows about 7·5 per cent. of potash to 7 per cent. of soda, and Rosenbusch points out that the extinction-angle of 12° corresponds approximately to the medium angle between orthoclase on the one hand and albite on the other.

As a further test of the probable nature of this felspar in the Shap rock, I have recently carefully analysed an average sample of a large hand-specimen, with the following result:—

	per cent.	
Silica	53·10	
Alumina	23·60	
Ferric oxide	8·50	*Ferrous* oxide not determined.
Lime	3·16	
Magnesia	1·62	
Potash	4·67	
Soda	4·05	
Water	0·55	
	99·25	

It will be seen that the relative proportions of potash and soda do not vary appreciably from those in the Frederiksvärn felspar, and as the alkali-bearing minerals present in this rock, other than felspar, are quite insignificant in amount (merely the very small proportion of micas) we may look on all this alkali as practically representing the felspar. This makes the resemblance to the Frederiksvärn mineral satisfactorily complete, and it is an interesting thing to observe its occurrence, as a new formation, in a rock altered by contact-action. The case is of all the more

interest because it does not seem unreasonable to believe that the fine striation seen in the felspars of so many contact-rocks is really due to the same thing, though it is not possible, in most cases, to obtain such good evidence, microscopical and chemical, as this special rock has afforded.

If we further glance at the analysis we see that it gives a striking proof of the incorrectness of the supposition, sometimes made, that high percentage of alkalies tends to exclude the formation of sillimanite and andalusite. Both minerals are abundant in this rock, and yet the alkali-percentage is certainly high.

If the alkalies are calculated all as orthoclase and albite they correspond to 61·72 per cent. of felspars, and we may take this as approximately the amount of those minerals present in the rock.

The high percentage of alumina is rather puzzling in a rock which is an altered ash. Indeed, taking the analysis as a whole, had I made it at the time when I looked on the rock as being an altered slate, I should have regarded the chemical composition as strongly confirming this view, as the analysis harmonizes better with this than with any other supposition. Indeed, with the exception of the fact that the alkali-total is rather high, and the relative proportions of potash and soda are different, the figures are not strikingly unlike those of some of the analyses I gave, in a former paper, of Carboniferous clays. And the resemblance is still closer to some Lower Carboniferous shales which I have analysed more recently, in which the alkalies range from 7 per cent. to over 8 per cent.[1]

Of course the exact determination of the nature of this bed by Harker and Marr, from detailed study of the field evidence, is quite conclusive; and so this rock possesses one more useful point of interest, as it affords an instructive example of the danger and little value which may attach to conclusions drawn from laboratory studies of specimens, without due regard to careful investigation on the ground.

IX.—On Glauconite from Woodburn, Carrickfergus, Co. Antrim.

By A. Percy Hoskins, F.I.C., F.C.S.

GLAUCONITE may be described as essentially a hydrous silicate of iron and potash, but of very variable composition, and generally containing varying proportions of other bodies, such as alumina, lime, and magnesia. It is found at different horizons in the whole geological series of rocks from the Cambrian up to the most recent Tertiary layers, and, indeed, is particularly interesting in being one of the very few silicates which are in actual process of formation on the sea-bed at the present time. The physical characteristics of glauconite grains are practically the same throughout the series, the normal colour being dark green, but sometimes

[1] See also an analysis by me of one of the altered Silurian "flags" at Shap (Geol. Mag., January and February, 1894), in which the total alkali is close on 8 per cent.

being yellowish, greyish, or even almost red. These variations of colour, however, mean at least the commencement of decomposition. The size of the grains is usually about one millimetre in diameter, and although much larger masses are sometimes found these are merely agglomerations of the smaller grains. Under the microscope the grains appear quite homogeneous unless some foreign body is enclosed, or, as sometimes occurs, the commencement of decomposition gives a more or less zonary appearance to them.

The following details have been given me by Miss S. M. Thompson, who kindly forwarded me the specimen used for analysis: "The glauconite grains occur in a cliff of the so-called 'chloritic sandstone' division of the Upper Greensand. The Woodburn River has cut through the Cretaceous rocks in the Knockagh Mountains, and has exposed this face of highly fossiliferous greensand." The specimens were collected from a calcareous sandstone, below the zone of *Inoceramus Crispi*.

The method adopted by Miss Thompson for obtaining the grains was this: The rock was pulverized and washed in a muslin bag until the water ran off tolerably clear; the powder was dried and sifted through coarse muslin, and then, with the help of a lens of low magnifying power, the grains of glauconite were picked up by means of a very fine sable-brush moistened in a tiny vessel of distilled water, into which the collected grains were dropped from the brush. The field of the lens was large enough to admit of this little vessel of water and a tray of glossy brown paper (upon which pinches of the powdered rock were shaken) at the same time, so that no time was lost in dropping the glauconite into the water as quickly as it was gathered. Great care was taken to have the grains as uniform as possible in size and colour. The sample received for analysis weighed a little over one gramme. It consisted of dark green granules of rather less than one millimetre in diameter, very homogeneous and of a rounded contour, intermixed with a few white particles. The grains were soft and readily powdered. The powder was treated with cold dilute hydrochloric acid,[1] to remove any residue of calcium carbonate, was well washed, and dried at 90° C. in an air-bath, and the resulting green powder was taken for analysis.

0·3575 grm. was decomposed with moderately concentrated sulphuric acid, the silica separated in the ordinary way, and the solution used for the determination of total iron, alumina, lime, magnesia, potash, and soda by the usual methods. 0·1975 grm. was ignited for combined water and organic water. 0·2780 grm. was decomposed by heating in a current of CO_2 with moderately concentrated sulphuric acid, and triturated with standard permanganate of potash for ferrous oxide. The results obtained are given in Column I.

[1] Careful subsequent investigations show that any decomposition which may occur during this preliminary treatment with dilute acid has an inappreciable effect upon the figures of the final analysis. Prolonged treatment with dilute acid tends, however, to remove iron, etc., and to heighten the percentage of silica in the residue. Thus a cold solution containing only 0·5 per cent. hydrochloric acid, acting for 39½ hours, extracted 25 per cent. by weight of the constituents of the glauconite.

Remembering what has been already said upon the variable composition of glauconite, it is not surprising to find that this example shows some deviations from the figures given for other glauconites, although in some particulars these differences are noteworthy. To illustrate this, and also to show how other glauconites vary among themselves, two summaries of analyses are appended. Column II shows the mean of analyses by Sipöcz of four samples of marine glauconite from the "Deep Sea Deposit" volume of the "Challenger" Report.[1] These were all taken at a depth of 410 fathoms, and in lat. 34° 13′ S. and long. 151° 38′ E.; yet, taken as they were from practically the same spot, the variations are most pronounced, especially in the essential constituents, silica, ferric oxide, potash, and water. Our Woodburn glauconite shows, however, many differences from all these "Challenger" analyses, and we may note among the essentials that the silica is over 13 per cent. lower than the mean of the four, and more than ten per cent. lower than the least of these; the ferric oxide, though higher than the lowest, is still more than four per cent. less than the mean; the potash is nearly double the highest figure given by the four, while the water is somewhere about the mean. One great difference observable is in the ferrous oxide, where, against a maximum of 1·95 per cent. in the modern marine glauconite, the Woodburn sample shows 16·81 per cent.

Below I have given a *résumé* of twelve analyses of glauconite from rocks which may be regarded as fairly similar to ours, and which are published in Dr. C. Hintze's "Handbuch der Mineralogie."[2] In their selection I have been aided by Prof. Cole. Here again, though we might fairly expect a closer correspondence with our own than in the case of the modern glauconite, we find in comparing them with each other, and with our Woodburn mineral, the same discrepancies in nearly every particular, the silica, for instance, varying from 58 per cent. to a little over 43 per cent., which figure is, however, still somewhat higher than ours. It will be noticed, however, that the ferrous oxide, which is so low in the modern glauconite of Table 1, gives us in Table 2 figures much more nearly agreeing with the glauconite of Woodburn.

The one point which does seem to come out clearly in this comparison is the relative poverty in silica of the Woodburn specimen, though even that is not much below the lowest in value in the mineral analyses quoted. In this connection it is worth noting that in the "Challenger" results the percentage of silica is lowest, and that of potash is highest in those cases in which the green, and especially the dark-green, casts predominate, casts agreeing in appearance with those composing the whole of our Woodburn specimen. Whether this is merely a coincidence, or has a definite significance, is not as yet certain. The fact that where the dark-green casts are most numerous the mineral particles and

[1] Report on scientific results of the voyage of H.M.S. "Challenger"; "Deep Sea Deposits" (1891), pp. 458-460.

[2] Hintze, "Handbuch der Mineralogie," p. 850. Analyses I, II, IV–XI, XIII, and XIV.

siliceous organisms are few, probably accounts, to a large extent, for the variation in silica.

It is just possible that at Woodburn the alkalies may be introduced into minerals capable of retaining them in combination, through the percolation of waters from the large salt deposits of Carrickfergus.

It may be interesting here to notice the figures given in Column III, from the volume of the "Challenger" Report referred to above, for a reddened glauconite in which the silica is exceptionally low. To this analysis the following remark is attached: "The high percentage of ferric oxide and water points to a decomposition of this mineral, which has been transformed into limonite, as is often the case in glauconite from the geological strata, with loss of silicic acid and potash, but this explanation can hardly be given for this specimen, which consists of casts from a coral sand." But no alternative suggestion is made, and neither will the suggestion hold in the case of our own glauconite; for, while the silica is low, neither the ferric oxide nor the water is particularly high, while the potash is seemingly higher than usual. Moreover, the casts are green, and show no signs whatever of decomposition into limonite. Professor Cole has suggested that possibly in the course of ages silica has actually been abstracted in solution; but in this case, since the silica must have been in combination when present in the mineral the grains should show some signs of the decomposition which must have taken place, and no such signs are visible. The only conclusion to be arrived at in the present state of our information is that the glauconite from Woodburn, when originally formed, was a variety containing an unusually small percentage of silica.

I trust I may have a further opportunity of examining specimens of glauconite from this locality, with a view to determining whether the material is constant in composition in different zones.

In conclusion I wish to express my sincere thanks for the kind assistance I have received from Miss S. M. Thompson, of Macedon, Belfast, and Professor Grenville A. J. Cole, of the Royal College of Science, Dublin, in the preparation of this note.

	I. Glauconite of Woodburn, Co. Antrim (A. P. Hoskins).	II. Mean of four analyses of glauconite given in the "'Challenger' Report on Deep Sea Deposits" (Sipöcz).	III. Reddened glauconite, 155 fms.; lat. 11° 38′ 15″ S., long. 143° 59′ 38″ E.; "'Challenger' Report on Deep Sea Deposits," p. 460 (Sipöcz).
SiO_2	40·00	53·61	27·74
Al_2O_3.....	13·00	9·56	13·02
Fe_2O_3.....	16·81	21·46	39·93
FeO	10·17	1·58	1·76
CaO	1·97	1·39	1·19
MgO	1·97	2·87	4·62
K_2O	8·21	3·49	0·95
Na_2O	2·16	0·42	0·62
H_2O	6·19	5·96	10·85
Total.....	100·48	100·34	100·68

Résumé of twelve analyses of glauconite selected from those quoted by Dr. C. Hintze, "Handbuch der Mineralogie," p. 850 (1892).

	Mean.	Max.	Min.	Remarks.
SiO_2	50·27	58·17	43·60	
Fe_2O_3.....	17·94	32·80	Nil.	Not stated in three analyses.
Al_2O_3	5·69	10·09	1·50	
FeO	8·16	21·78	2·64	
CaO	0·78	3·21	Nil.	Absent in eight analyses.
MgO	2·29	6·21	Nil.	Absent in four analyses.
K_2O	6·12	8·79	3·10	
Na_2O	?	0·91	0·21	Only occurs in two analyses.
H_2O	8·23	14·70	4·71	
	99·48			

X.—Notes on "The Great Ice Age" in Relation to the Question of Submergence.

By Dugald Bell, F.G.S.

THE new edition of Dr. Geikie's esteemed work has already been noticed at some length in this Magazine.[1] The present writer desires to add some notes—freely, but with all respect to the author—on a special part of the subject, viz. that relating to the "high-level shelly deposits," and their bearing on the question of submergence during the Glacial epoch.

I.

In his "Fragments of Earth-Lore," published about two years ago, Dr. Geikie intimated that he no longer believed in a "great submergence," during which the British Isles were "largely" sunk under the sea. "The marine shells," he said, "in the high-level drift deposits of our islands are 'erratics' carried by the ice-sheet which occupied the basin of the Irish Sea. That the low grounds were submerged to some extent before the advent of that ice-sheet, there seems to be little doubt; but the amount of the submergence has not been ascertained,—probably it did not exceed a few hundred feet."[2]

This announcement was extremely gratifying to those who for some years past had been calling in question any "great submergence," and pointing out the striking lack of evidence in its favour.

It turns out, however, that though Dr. Geikie thus abandoned a "great submergence" of about 1400 feet, which was thought to be proved by "fragments of marine deposits" in Wales and Ireland, he still holds by one of from 500 to 600 feet, which he seems not to consider "great" (though demonstrably it would have placed the British Isles very "largely" under water), and the proof of which depends on one or two instances of "high-level shelly clay" found in the west and north of Scotland. Indeed, we may say it now depends on only *one* instance, for the other is in this edition "conspicuous by its absence."

[1] See January, 1895.

[2] *Op. cit.* p. 173.

Chapelhall.—We allude to Chapelhall, near Airdrie, which for some forty years has been the "stock" instance to prove a submergence in Scotland of about 500 feet. In the preceding edition of this work, Dr. Geikie made much of this instance, referring to it repeatedly as clearly proving submergence. "Evidently," he said, "this shelly clay marks an old sea-bottom, when the sea rose not less (indeed certainly more) than 526 feet above its present level." And he proceeded to point out the great series of changes to which the section bore witness: (1) "a time when the great central valley of Scotland brimmed with glacier ice"; (2) a time when "a free ocean flowed over the site of the district in question"; and (3) a time when "another mighty ice-sheet again overflowed the land."[1]

This Chapelhall section was thus of capital importance to Dr. Geikie in working out the details of the Glacial period; and, as we have seen, he made much of it. What does he say about it in the present edition? Absolutely nothing! It is dropped out of view entirely, without a word of explanation!

We submit this is apt to be extremely puzzling to his former readers. They will naturally wonder *why* Chapelhall is now so completely set aside and ignored. Of course, if they have any curiosity in the matter, they may learn from other sources—but why not also here?—the simple facts. The meagreness of the evidence on which this instance rested having been pointed out, and doubts having been expressed as to whether, in any case, the "deposit" was "in place," a re-examination of the locality was made by a committee appointed for the purpose. The result was entirely *negative*; no trace of the "shelly clay" could be found![2] This accounts for its total disappearance from Dr. Geikie's book. Still, as we say, its absence might have been alluded to, and a brief *In Memoriam* inserted where it once figured so largely. It seems scarcely becoming to let one's favourite facts thus sink out of sight—

"Without the meed of some melodious tear!"

But, "fortunately" (as another eminent writer used to say when facts were found to suit his theory)—"fortunately," since his last edition was published, another instance has emerged on which, now that Chapelhall has "collapsed," Dr. Geikie can still take his stand in maintaining a submergence of about 500 feet. That instance is Clava, in the valley of the Nairn, near Inverness, which now takes the place of Chapelhall superseded or defunct. Dr. Geikie makes up for his reticence regarding Chapelhall by a full and particular account of Clava. If we may adapt a well-known Scotch story, it is now the "a'e button," which has to bear a quite enormous "responsibility." It must therefore be looked to with some degree of care.

Clava.—This shelly clay was described by Mr. J. Fraser some years ago[3] as occurring underneath Boulder-clay at a height of

[1] Second edition, pp. 175–6.
[2] See Trans. Geol. Soc. Glas., vol. ix. Reports Brit. Assoc., 1894.
[3] Trans. Edin. Geol. Soc., vol. iv.

503 feet above the sea, and indicating a submergence of at least that amount "prior to the accumulation of the overlying Boulder-clay." Dr. Geikie continues—"Doubt having been expressed as to whether the shelly clay was really *in situ*, a committee appointed by the British Association duly investigated the beds. . . . The majority of the committee . . . . are of opinion that the shell-bed is *in situ*. . . . . The minority . . . . incline to the view that the shelly clay is not *in situ*, but has been dragged or pushed into its present position by a *mer de glace* . . . . from the basin of Loch Ness." It is admitted that "the stones in the overlying Boulder-clay, and the trend of the glaciation of the neighbourhood, indicate an ice-movement from south-west."[1]

Dr. Geikie, not content with merely stating the facts, takes side strongly with the majority on this question, and indulges in some mild pleasantry at the "remarkable performance" which the minority ascribe to the glacier-ice. Well, it is very much a choice of difficulties; but we shall perhaps see immediately that *more* remarkable performances are required by Dr. Geikie's explanations of the phenomena, and on his own showing, not only for the ice, but also for the sea and for the solid land!

We are told that the minority "appear to have adopted this peculiar explanation of the evidence because they cannot find elsewhere any proofs of a submergence of the land during Glacial times" [*i.e.* to anything like the same extent, or beyond "100 feet or thereabouts"]. "They think that if Scotland had ever been depressed to the extent of 500 feet, the sea would have left abundant evidence of its former presence." Precisely; and in this Dr. Geikie might have been expected to agree with them. Referring to the "Till" of Northern Europe, he writes—"No evidence of marine action in the formation of the stony clay is forthcoming—not a trace of any sea-beach has been detected. And yet, if these clays had been laid down in the sea . . . . surely such evidence as I have indicated ought to be met with."[2] Why, then, is he so severe upon the minority for thinking that if Scotland had been submerged to the extent of 500 feet "the sea would have left abundant evidence of its former presence"?

And why is the minority's explanation "peculiar"? It cannot be so in itself, as the numerous instances of shells and shelly clay imbedded in "Till," to which reference is made in this volume, abundantly show. Besides, it is distinctly adopted by the author himself to account for deposits of "marine drift" at an elevation of 1400 feet in North Wales.[3] The uplifting of these deposits to such a height by the ice is surely a much more "remarkable performance" than the transport of those at Clava to only 500 feet. Indeed, it is not easy to see on what principle, having admitted the transport by ice of marine remains to a height of 1400 feet, one can make a stand against admitting their transport by the same agency to a height of 500 feet. In this case, surely the greater includes the less, and

[1] "Great Ice Age," pp. 139–141.
[2] p. 433. [3] pp. 160, 281, 371.

makes the less not only probable, but in many cases perfectly certain.

But perhaps it is meant that there is something "peculiar" in the Clava deposit itself, which forbids this explanation being applied to it. Its "extent" is referred to, and its "maintaining a horizontal position, and exhibiting no trace of deformation or disturbance." These are points, however, on which the evidence, as given in the Report, does not appear to be at all conclusive; on one or two of them, indeed, it inclines quite the other way.[1] We believe it can be shown, keeping to what is *proved* in the Report, that whatever difficulties the features of the deposit present on the one hand to the ice-transport theory they present still greater difficulties on the other to the theory of a marine deposit *in situ*. But to this we shall return.

Meantime we may note, in passing, that Dr. Geikie unduly heightens the case against the ice-transport theory by representing its purport to be that the shelly clay was "pushed or dragged forward under the ice-sheet" for so many miles. The minority, however, did not express it in these terms, nor did they define the precise mode in any terms; and they may very properly object to Dr. Geikie doing it for them. Certainly, by his own account, this mode does not "necessarily follow." We are elsewhere told of stones or boulders which, "once imbedded in the ice," may have been carried for "a hundred miles without suffering abrasion.[2] It seems hard on the shelly deposits that they could not in some instances (as frozen masses, perhaps) be transported in the same gentle fashion, for ten or twelve miles!

But Dr. Geikie proceeds to discuss the case on more general grounds, into which we must now shortly follow him.

II.

The first part of the more general ground which Dr. Geikie takes up in arguing for a submergence during Glacial times of over 500 feet, has reference to the non-fossiliferous character of the "Upper Boulder-clay." The statement that "had such a degree of submergence ever taken place prior to the advance of a general ice-sheet, we should surely find the ground-moraine of that ice-sheet more or less abundantly charged with relics of marine life," he meets by saying, "this does not necessarily follow."[3]

The author has evidently got some new light on the subject since the date of his previous edition. He then alluded to this absence of marine organisms in the Upper Boulder-clay as an almost insuperable difficulty against the theory of a submergence. "Why," he wrote, "we may ask, does not the Upper Boulder-clay of the Central Lowlands (a great proportion of which must have been submerged before the last ice-sheet overflowed Scotland) contain broken shells, and afford other indications of the latest confluent glaciers having usurped the bed of the sea? That is a very hard question to answer, and I fear we must wait some time yet for an

[1] Brit. Assoc. Report, 1893. [2] p. 204. [3] p. 141.

adequate solution of the difficulty."[1] But now he announces with easy *nonchalance* that the difficulty does not exist—"it does not necessarily follow!"

We may remark, in passing, that there are many things which do not "necessarily follow," but which yet are the only probable things we can accept or reason upon. That a submergence of 500 feet or 600 feet should leave traces of itself in the shape of relics of marine life, more or less abundant, in the Boulder-clay of the succeeding glaciation, seems to us as nearly a necessary consequence as anything we know of in geology; at all events, as in many ways, and by many degrees, more probable than that such traces should all have been removed or destroyed. But let us look at Dr. Geikie's reasons for now making so light of the difficulty which formerly oppressed him.

(1) He says, "a depression of 500 feet or 600 feet would drown only a narrow belt of coast-land, and a relatively small area in the midland of Scotland."

With a recollection of Lyell's old sketch-map, showing the change that would be produced on the contour and extent of the British Isles by a subsidence of 600 feet,[2] we read this statement with considerable astonishment. Let the reader look at any good "Orographical Map" of Scotland, such as that prefixed, for example, to the volume already mentioned, "Fragments of Earth-Lore." There he will see clearly the broad tracts that would be submerged by a depression of 500 feet—in Caithness, around the Moray Firth, in Aberdeenshire, in Strathmore, in Fife, in the Forth and Clyde valley, in Berwickshire, Dumfries, Kirkcudbright, Wigton, Ayr; in all cases running far up into the river valleys; not to speak of innumerable detached areas and winding belts, in some cases of considerable size, all along the western coast. Why, a depression of 500 to 600 feet would drown nearly all the arable land of the country, all the "broad lowland tracts," straths, and "carses," described so graphically in the volume referred to. This as regards Scotland; while in England and Ireland the area submerged would be relatively still more extensive—in fact, the greater part of the country. We may take it, then, that the extent of the area gives emphasis to the question,—If it were all submerged prior to the last glaciation, why does its Upper Boulder-clay not contain fragments of shells, and afford other indications of the former presence of the sea?

Dr. Geikie adds (2) that "the submergence may not have been long-continued," and (3) that "the conditions may not have favoured the abundant development of marine life." But these seem to be purely imaginary suppositions, thrown in without a word in their favour. We need not, therefore, discuss them.

(4) We pass on to notice the last and apparently chief reason given by the author to account for the absence of marine organisms in the Upper, or supposed post-submergence, Boulder-clay. It is,

[1] Second edition, p. 390.
[2] "Antiquity of Man," third edition, p. 278.

that while the submergence may have been short, the succeeding glaciation may have been—or rather, he seems to say, must have been—long; and as it continued, and "sub-glacial erosion" was carried on, "the supply of shelly deposits at and below the level of 600 feet would tend to become exhausted, and the Boulder-clay continually passing outwards from the land would eventually contain no shells."[1] This is our old friend, the theory of the "complete sweeping-out by the second glaciation," which we humbly thought had been disposed of some time ago,[2] but of which, as it now comes up again under the wing of Dr. Geikie, it is necessary anew to take some cognizance. We think we can demonstrate (with Dr. Geikie's help) the impossibility of the ice performing what is thus ascribed to it.

(*To be continued.*)

REVIEWS.

I.—Crystallography, a Treatise on the Morphology of Crystals. By N. Story-Maskelyne, M.A., F.R.S. Octavo, 512 pp., 398 figs., and 8 plates. Oxford, Clarendon Press, 1895.

In one of his scientific aphorisms Goethe pronounces criticism upon Crystallography; this science, he says, has about it something of the Monk and the Old Bachelor: it exists for itself alone, it has no applications, it leads to no results; and yet, he adds, it has by some means captivated and retained its hold upon some of the acutest intellects; this fact is due, he supposes, to the extent and the complexity of its details, which supply almost inexhaustible material for the active mind.

The criticism is no longer true. When Goethe wrote these words the geometrical principles of Crystallography, now known to be remarkably simple and definite, had not been fully established; outside pure Mineralogy its applications at that date were indeed few. But now the Monk has called upon his neighbours, and the Old Bachelor flirts with the spinster sciences—with Geology and Chemistry in particular the most friendly relations have been established, and Petrology, the result of the former liaison, is a young science fast growing to robust maturity.

Whether they wish it or no, a large proportion of modern geologists must acquire some knowledge of Crystallography, without which the study of rocks is almost impossible. Maskelyne's "Morphology of Crystals" will not, it is true, satisfy all their requirements, because it does not deal with the optical and other physical characters, but it is, and must long remain, the standard book to which the geologist must turn for information about the geometry of the subject.

Beginning with the later portions of the book, the reader will find in chapter viii an account of the manner in which crystals are measured; the preceding chapter contains a detailed account of the

[1] p. 142. [2] Trans. Geol. Soc. Glasgow, vol. ix, pp. 109, 110.

various systems and their subdivisions, illustrated with numerous figures and examples; while the second to the sixth chapters discuss the relation between a series of crystal faces, the properties of zones and axes, and the nature of crystal symmetry.

By inverting the order of the chapters, we have here indicated what may be regarded as an objection to the present plan of the book from the point of view of a general reader; the first six chapters contain much that might with advantage have been postponed to later pages. Subsidiary theorems on stereographic projection, on the transformation of axes, and on tautozonal planes, are not calculated to encourage a beginner, and might well have been deferred to a chapter preceding that on crystal calculation. The chapter on crystalloid symmetry, the most original and interesting in the book, might have been introduced almost at the outset. As it is, the first chapter, on the general characters of crystals, is in parts almost unintelligible to a reader who possesses no knowledge of crystal physics.

Let the student, however, boldly begin with chapter v, returning to the preceding pages when necessary, and proceed with all possible speed to chapter vii; and he will find the book a veritable mine of wealth, and one which will repay careful study.

In fact, having stated our objections to the general plan of the book, we may hasten to make reparation by asserting that it is one which if read at all should be read thoroughly; for example, the great theoretical importance of the equations obtained on page 96 will scarcely be appreciated until pp. 112–117 have been mastered. These and the other more difficult parts of the book we may safely commend to the more mathematical reader, to whom they will afford considerable pleasure.

In most subjects three or four good English text-books exist, and it is sometimes difficult to choose between them. In the science of Crystallography there is no such embarrassment. To Professor Maskelyne's book both teacher and student can confidently be referred for two very good reasons: because it has no rival in the English language, and because it is a thoroughly sound and excellent book. A second volume, dealing with the physical properties of crystals, is promised, and will doubtless be expected with interest by geologists, to whom it should be even more useful than the present volume.

II.—Thirteenth Annual Report for the Year 1893 of the State Geologist. Vol. II: Palæontology. Transmitted to the Legislature of New York, March 1, 1894. One Vol. pp. 338. Plates 23–54. With Part II of an illustrated "Handbook of the Brachiopoda." By James Hall, assisted by John M. Clarke. (James B. Lyon, State Printer, Albany, 1894.)

THIS volume, just received, opens with an instructive summary of the "Evolution of the Genera of the Palæozoic Brachiopoda," a tabular classification into families, and descriptions of new species. These form extracts from the Final Text of vol. viii, part ii, of the

"Palæontology of New York," and are first issued in this Report on account of the continued delay in printing the volume of quarto plates which should have accompanied the conclusion of Professor James Hall's and Mr. John M. Clarke's labours on the Brachiopoda.

A Memoir by Mr. W. H. Sherzer on "Platycnemic Man in New York" follows. The prehistoric remains of this type of humanity are of frequent occurrence on the American continent, ranging from Peru to Mexico, Florida to Wisconsin, from Ohio to New Jersey and Massachusetts. It has been also recognized and described from Oceania and from the Grand Canary Islands, and discussed by Busk, Falconer, Broca, Guillemard, and others. The New York specimens were obtained from Canandaigua lake, and are characterized by the perforation of the humerus, the flattening of the tibia, with curvature of its shaft and head, and compression of the femur, all "*simian* characters departing from the normal human skeleton." These characters, Mr. Sherzer considers, were not caused by "rickets," as by some maintained, that they can no longer be regarded as a sexual distinction, for "they are now known to occur in both sexes." He believes them to have been brought about by corresponding similarities in life habits. The one common habit capable of sufficiently reacting upon the skeleton of both early Man and the Apes "could have been none other than that of tree-climbing, after the fashion of our modern Apes, with the soles of the feet firmly pressed against the tree and the body held off at arm's length." He notes further that the percentage of platycnemism is greater among the most ancient remains found, and diminishes gradually towards modern times, and concludes that arboreal habits would be of necessity more resorted to in primitive times, when man's powers of offence and defence were most limited. Thus the tree-climbing and propensities of the youthful scions of civilized races are satisfactorily accounted for. They are merely recapitulary instincts repeating that period in the history of the development of the race when man lived among green trees, still the most restful and consequently the natural colour for the eyes.

Mr. George B. Simpson next discusses, with the aid of numerous illustrations, the "Different Genera of Fenestellidæ," and supplies a very useful "Glossary and explanations of specific names of Bryozoa and Corals," previously described and figured in vol. vi of the "Palæontology of New York" and preceding "Annual Reports."

The remainder of the Thirteenth Report is devoted to Part II of "An Introduction to the Study of the Brachiopoda," by James Hall and John M. Clarke, forming the concluding portion of that excellent students' "Handbook of the Brachiopoda," of which Part I was issued in 1894 (see GEOL. MAG., Dec. IV, Vol. I, No. 360, p. 279, 1894). This treats of the Spiriferoids, Atrypoids, Rhynchonelloids, and Terebratuloids, gives concise descriptions of genera new and old, accompanied with numerous woodcuts, many of which are original productions and represent the results of long-continued and patient research. The thirty-one plates of generic illustrations which complete the handbook are especially welcome,

as we get here the first figures of many new genera founded by the authors among the articulated Brachiopoda in the course of their successful labours. We heartily congratulate them on the results, and can only express the hope that the publication of the quarto edition of the Plates needed to complete their great work will not be again delayed by "malign influences" and lack of fiscal support.

An alphabetical index to genera and subgenera is appended, in which we note Mr. W. D. Mathews' siphonotretoid genus *Trematobolus* is not included among the synonyms, although it is omitted from the generic list classified into families in the "Systematic Classification" with which this most useful and interesting handbook concludes, and to the main features of which, through the courtesy of the authors, we have already referred (see GEOL. MAG., March 1895).

With regard to systematic classification, however, and the vexed questions of genetic relationships and affinities, the last word has by no means been said. There is still room here for diversity of opinion, more especially in connection with the relationships of the primitive forms which present such a mixture of characters. Mr. Charles Schuchert, we learn, has nearly completed a "Catalogue of Brachiopoda," which, we feel sure, will further illuminate this most difficult subject. New genera and species are almost daily described throughout the world. Dr. W. H. Dall has a paper in the press defining seven new recent forms from the Pacific Ocean, one belonging to a new subgenus of the Rhynchonellidæ of a very interesting type.[1] The full history of that widespread deep-water discinoid, the so-called *Discinisca Atlantica*, still remains unwritten. A grand opportunity awaits a well-trained embryologist who would turn his attention to the developmental history of the living British Cranoids and Discinoids. Such an investigation, if successfully carried out, might throw much light on obscure points in the early history of these ancient stocks. Will no British student do for our Cranoids and Discinoids what Morse, Dall, Brooks, Beyer, and Beecher have done for the Terebratuloids and Linguloids of the American shores? Palæontologists would owe him a debt of gratitude, and science be greatly advanced thereby. AGNES CRANE.

III.—SUR L'ORIGINE DE LA DOLOMIE DANS LES FORMATIONS SÉDIMENTAIRES. Par M. C. KLEMENT. Bull. d. l. Société Belge d. Geol., etc. Tome IX (1895), pp. 3–23.

AFTER reviewing the very extensive literature relating to the mode of occurrence and origin of dolomite, the author describes a series of experiments in which a solution of sulphate of magnesium and chloride of sodium is made to act at various temperatures on arragonite and calcite. He finds that in the presence of a saturated solution of common salt at a temperature of 91° C. sulphate of magnesium will act on the powder of

[1] *Frieleia Halli*, Dall, a smooth Pacific species allied to *Hemithyris* (?) *lucida*, Gould, from Japanese waters.

arragonite in such a way as to give rise to a product containing 42 per cent. of carbonate of magnesium. Below 60° C. the action is very slight, but between 60° and 91° there appears to be for each temperature a certain maximum amount of replacement possible. When the solution is not concentrated with common salt the sulphate of magnesium acts much less energetically. The powder of iceland spar, unlike that of arragonite, is scarcely acted upon at all under similar circumstances. The powder of corals, on the other hand, is affected in the same way as that of arragonite. Thus *Madrepora humilis* from the island of St. Thomas yielded a product containing 41·9 per cent. of carbonate of magnesium after treatment for 47 hours at 90° C.

The author shows that the product formed in his experiments is not dolomite, but a mixture of the two carbonates. He considers, however, that true dolomite may be formed from such a mixture by secondary processes.

The author finally discusses the question as to whether the conditions of his experiments can be realised in nature on a large scale. Chloride of sodium and sulphate of magnesium are both present in sea-water, which may be concentrated in the closed lagoons of certain atolls. The débris of corals composed of arragonite is present, and the rays of the sun in tropical regions are capable of raising the temperature of such closed basins far above 60° C. He concludes, therefore, that "dolomite is formed by the action of sea-water, concentrated in closed basins and heated by the solar rays, on the arragonite deposited by organisms, in such a way that a mixture of the carbonates of calcium and magnesium is first produced, and subsequently converted into dolomite."

J. J. H. T.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 22, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On a Human Skull and Limb-bones found in the Palæolithic Terrace-Gravels at Galley Hill, Kent." By E. T. Newton, Esq., F.R.S., F.G.S.

A human skull with lower jaw and parts of the limb-bones were obtained by Mr. R. Elliott from the high-terrace gravels at Galley Hill, in which numerous Palæolithic implements have been found.

The skull is extremely long and narrow, its breadth-index being about 64; it is hyperdolichocephalic; it is likewise much depressed, having a height-index of about 67. The small extent of the cranium in both height and width shows that it has undergone little or no post-mortem compression, although it has become somewhat twisted in drying. The supraciliary ridges are large, the forehead somewhat receding, the probole prominent, and the occiput flattened below. All the chief sutures are obliterated. Three lower molars and two

premolars are in place and are well worn, the three molars being as nearly as possible equal in size. The limb-bones indicate an individual about 5 feet 1 inch in height.

These remains are compared with the fossil human relics which have been found in Britain and on the Continent of Europe, as well as with the dolichocephalic races now living, and their relations to the 'Spy,' 'River-bed,' 'Long-barrow,' 'Eskimo,' and other types are pointed out.

The gravels, in which these human bones were found, overlie the Chalk at a height of about 90 feet above the Thames, and are about 10 feet thick. They form part of the high-terrace gravels extending from Dartford Heath to Northfleet, and their Palæolithic age is shown by the numerous implements which have been found in them, as well as by the mammalian remains which have been met with in similar beds near by, although not at Galley Hill. The human bones were seen *in situ* by Mr. R. Elliott and Mr. Matthew Heys, both of whom, in letters, speak positively as to the undisturbed condition of the 8 feet of gravel which overlay the bones when discovered.

2. "Geological Notes of a Journey round the Coast of Norway and into Northern Russia." By G. S. Boulger, Esq., F.L.S., F.G.S.

The author accompanied the Jackson-Harmsworth Polar Expedition as far as Archangel, and returned by way of the River Dvina. His observations relate mainly to four points: the origin of the foliation of the Norwegian gneiss; the question of raised beaches on the north-western coast of Norway; the boulders and boulder-formation of Northern Russia; and the Trias of the Dvina valley.

Between Christiansund and Tromsö the author was struck with the wide-sweeping folds of the foliation-planes of the gneissose rocks, which appeared to him more readily explicable on a theory of dynamo-metamorphism of rocks originally in part igneous, than by any process of diagenesis. He notes that the terraces observed in the transverse fjords would be perfectly explained by the formation of ice-dammed lakes, though the terraces of the Gulf of Onega seemed less dubious raised beaches than those of the north-west of Norway. He confirms the views of previous writers that many of the boulders of the boulder-formation of Northern Russia are of Scandinavian origin. The beds on the Dvina consist of sands and loams, often coloured red, with bands of alabaster and anhydrite. The strata are horizontal or inclined at a low angle. North of Ustyug Veliki the strata are marked as Permian on the Russian maps, and those to the south as Trias, but the author saw no perceptible break in the succession.

3. "On some Foraminifera of Rhætic Age, from Wedmore in Somerset." By Frederick Chapman, Esq., F.R.M.S. (Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.)

(1) The author has examined six examples of clays and limestones from different horizons; these were collected by Mr. W. A. Sanford, F.G.S., from a quarry south-east of the village of Wedmore, which has yielded Megalosaurian remains. The rocks in this quarry are

regularly stratified, and characteristic Rhætic fossils have been obtained from them by Mr. Sanford.

(2) The microscopical details of the various clay-washings are given, and the great abundance of some forms of the acervuline foraminifer *Stacheia* is noticed, included amongst which are forms that have been previously described under the name of "*Psammosiphon*" by Vine, and "Plaques de Rayonnés" and "*Asteracanthion*" by MM. Terquem and Berthelin; the former occurring in Silurian strata, and the latter in the Lias. The Rhætic examples of the genus *Stacheia* have numerous aggregated crystals of zeolites (?), of which, however, only impressions remain, included in the material of the tests.

(3) In a comparison made with the foraminiferal faunæ of the older and younger rocks respectively, the Rhætic fauna shows marked affinities with both the Upper Palæozoic and the Liassic facies.

The bathymetrical aspect of the foraminifera from Wedmore is, generally speaking, that of a shallow-water deposit. The genus *Stacheia* is represented so abundantly in some of these Rhætic rocks that the fossils constitute distinct layers in the beds of clay in which they are found. *Stacheia* appears to resemble *Polytrema* in reference to its habitat, and also in the microscopical structure of its test, with the exception that *Stacheia* includes in the test-wall minute sand-grains and other foreign material.

(4) Twenty-six species of foraminifera, chiefly of arenaceous types, are described, nine of which are new forms, viz.: *Haplophragmium Rhæticum, Ammodiscus auriculus, A. fusiformis, Nodosinella Wedmoriensis, Stacheia intermedia, S. triradiata, S. dispansa, S. cuspidata,* and *Truncatulina stelligera.*

II.—June 5, 1895.—W. H. Hudleston, Esq., M.A., F.R.S., F.L.S., Vice-President, in the Chair. The following communications were read:—

1. "On a well-marked Horizon of Radiolarian Rocks in the Lower Culm Measures of Devon, Cornwall, and West Somerset." By George Jennings Hinde, Ph.D., F.G.S., and Howard Fox, Esq., F.G.S.

In the Lower Culm Measures the basal *Posidonomya* Beds and the Waddon Barton Beds with *Goniatites spiralis* consist of fine shales with thin limestones, and above these are the beds which form the subject of the present paper. The Upper Culm Measures consist of conglomerates, grits, sandstones, and shales, with occasional beds of culm. There is evidence of the partial denudation of the Radiolarian rocks during the accumulation of the Upper Culm Beds, as indicated by the presence of pebbles of the former in the latter.

The Radiolarian Beds consist of a series of organic siliceous rocks—some of a very hard cherty character, others platy, and yet others of soft incoherent shales. They are spoken of as the Codden Hill Beds—a name applied to them by previous writers, though the authors do not include in this series all the beds which have been referred to it by others. The term "Grits," which has been used in

connection with these beds, is a misnomer; there are beds which are superficially like fine grits, but they are found to be Radiolarian deposits.

The Codden Hill Beds occur along a comparatively narrow belt of country, a short distance within the northern and southern boundaries between the Carboniferous and Devonian systems. Starting with the northern exposures, the authors give a description of the beds as developed in various localities from the neighbourhood of Barnstaple (Codden Hill itself, situated 3 miles S.E. of Barnstaple, being a convenient starting-point), past Dulverton, to Ashbrittle in West Somerset. On the south the beds are traceable from Boscastle to the neighbourhood of Tavistock, and on the east side of the Dartmoor granite they are found near Chudleigh and Bovey Tracey.

At present there are not sufficient data for estimating the thickness of the Radiolarian deposits; but they are probably some hundreds of feet thick, though the whole does not consist of beds of organic origin. In a quarry in the Launceston district 50 feet of Radiolarian cherty rock are seen without admixture of shale.

A detailed description of the lithological characters of the rocks of the series is given, and analyses by Mr. J. Hort Player; a marked feature of their composition is the very general absence of carbonate of lime. The microscopic characters of the rocks are also described, and the small amount of detrital matter in the beds of the series is noted.

Forms belonging to 23 genera of Radiolaria have been recognized, included in the orders *Beloidea*, *Sphæroidea*, *Prunoidea*, *Discoidea*, and *Cyrtoidea*; in addition a scanty but significant fauna of corals, trilobites, brachiopods, and cephalopods is present in some thin shaly beds near Barnstaple. Nearly all the forms are diminutive. The trilobites are described by Dr. H. Woodward, the brachiopods by Mr. F. A. Bather, and the cephalopods by Mr. G. C. Crick. Of the 25 species of fossils other than Radiolaria which have been determined, several are only known elsewhere from the Lower Culm of Germany, while others are common to the Carboniferous Limestone of the British Isles and Belgium.

These fossils tend to confirm the view that the Lower Culm Measures are the deep-water equivalents of the Carboniferous Limestone in other parts of the British Isles, and not shallow-water representatives of deeper beds occurring to the north, as was formerly supposed. In connection with this it is worthy of note that the deep-sea character of the Lower Culm of Germany, which corresponds with our Lower Culm Measures, was maintained by Dr. Holzapfel even before the discovery of Radiolaria in the beds of Kieselschiefer furnished such strong evidence in support of this view.

2. "The Geology of Mount Ruwenzori and some Adjoining Regions of Equatorial Africa." By G. F. Scott-Elliott, Esq., M.A., B.Sc., F.L.S., and J. W. Gregory, D.Sc., F.G.S.

Ruwenzori is a mountain between the Albert and Albert Edward Nyanzas. Topographically it is a narrow ridge which extends for about 50 miles in a direction from N.N.E. to S.S.W. Its summit

attains a height of 16,500 feet. The western slope is at an angle of 22°; the eastern slope at about one of 4°. The authors describe sections across the ridge at right angles to its trend. These show that Ruwenzori is not volcanic, nor is it a simple *massif* of diorite. Epidiorite occurs only as banded sheets in the schists on the flanks of the mountain, and is not the central rock of the ridge. The strike of the flanking schists seems to run concentrically round the ridge as though the central rock were intrusive into them. The highest rock collected, a coarse-grained granite or granitoid gneiss, may be an intrusive igneous rock, but it may be part of the old Archæan series faulted up; there is nothing in its microscopical characters to separate it from the Archæan rocks, and the authors think it probable that this rock was raised into its present position by faulting. In this case Ruwenzori is simply composed of an orographic block or "scholl," which was at one time probably part of a wide plateau of Archæan rocks.

There is abundant evidence of volcanic action around Ruwenzori, for the plains, especially to the east and south-east, are studded with small volcanic cones, arranged on lines which radiate from Ruwenzori.

It is affirmed that evidence points to the former occupation of the Nyamwamba, Mubuka, and Batagu valleys by glaciers, *roches moutonnées* of typical character having been noted in the two former valleys.

The country round Ruwenzori consists of rocks which may be conveniently grouped into two series—one composed of gneisses and schists, and the other of non-foliated sediments. The former (the Archæan series) are of the type that has an enormous extension in Equatorial Africa, and forms the main plateau on which all the sediments and volcanic rocks have been deposited.

The sedimentary rocks are probably Palæozoic, possibly pre-Carboniferous, but in the absence of fossils it would be unsafe to go beyond this statement.

3. "On Overthrusts of Tertiary Date in Dorset." By A. Strahan, Esq., M.A., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The results given in this paper were obtained during a re-survey of South Dorset on the 6-inch scale. The disturbances can be divided into two groups,—the one being mainly of Miocene date, and the other of intra-Cretaceous (between Wealden and Gault) age. The former includes the Isle of Purbeck fold (which is the continuation of the Isle of Wight disturbance), the Ringstead fold, the Chaldon and Ridgeway disturbances, and the Litton Cheney fault. In the latter are placed the anticline of Osmington Mill, the syncline of Upton, and a part of the anticline of Chaldon; farther west the Broadway anticline and Upway syncline, a fault at Abbotsbury, and many other folds come into the same group. These earlier movements led to the well-known unconformity at the base of the Upper Cretaceous rocks.

The Isle of Purbeck fold is accompanied by a large thrust-fault,

by which the uppermost zones of the Chalk have been pushed in a vertical position under gently inclined lower zones. On the same line of disturbance at Lulworth Cove, the squeezing-out of plastic strata from a part of the fold where compression has been great, and the folding and packing away of such strata in a part where there was a tendency to gape, is described. Farther west the same disturbance is accompanied by inversion of a great thickness of beds, great compression, with vertical crush-planes and nearly horizontal slide-planes. The latter slope southwards, and the roof has moved northwards and upwards over the floor; these slide-planes have accompanied the phenomena of inversion.

The Ridgeway fold and fault resemble those of the Isle of Purbeck, but for some distance the thrust-plane has split, a part of it cutting into the Oolitic floor on which the Upper Cretaceous rocks were laid down, and causing a wedge of Oxford Clay, Cornbrash, and Forest Marble to be thrust over Wealden, Purbeck, Portlandian, and Kimmeridge Clay.

The Litton Cheney fault is connected with an anticline in the Chalk and Greensand which has been superimposed upon a syncline in Kimmeridge Clay and Corallian.

The intra-Cretaceous disturbances have been distinguished by the fact that Upper Cretaceous rocks rest undisturbed upon them, the difference in inclination amounting sometimes to 40°. This movement may have commenced before the Lower Greensand was laid down, but took place principally between the deposition of that formation and the Gault.

The features produced by the earlier movements were planed down before the Gault was deposited, and have had no share in producing the existing physical geography. The later movements, on the other hand, have determined the lines of drainage and the great physical features of the region.

CORRESPONDENCE.

DR. CALLAWAY AND METASOMATOSIS.

Sir,—My friend Dr. Callaway has been kind enough to send me a copy of a short paper of his in the Geological Magazine, in which he says that in my note on his views I have made "the astonishing error" of attributing to him an opposite opinion to that expressed by the words, "a mere gradation between two kinds of rock proves nothing as to the genetic connection between them," and that I have thereby misunderstood and misrepresented him; yet on the very next page he says of such gradation, without mentioning anything else, that it justifies certain conclusions about this connection. Is not this also the opposite to the above opinion?

But to try to be plain. I do not suppose that Dr. Callaway holds the general proposition—"If one rock passes into another in the field, one of them must be derived from the other," but I do think

he argues on the basis of the following: "The character of the stages by which one rock passes into another in the field *may* suffice by itself to prove that one of them is derived from the other." This also may be assented to; but the case when one rock is diorite and the other a quartz-schist, will, for few minds, be included amongst those in which such evidence *does* suffice.

Dr. Callaway illustrates his meaning by a piece of underdone beef, as though the matter were one of simple contact or thermo-metamorphism; but when he can show us how, by slicing, rolling, squeezing, or roasting, to convert a piece of lean meat into fat, or *vice versâ*, he will introduce a novelty into the kitchen, and experimentally illustrate what he wishes us to believe in the case of rocks.

Port Said, 12*th June*, 1895. J. F. Blake.

PHOSPHATIC CHALK AT TAPLOW, BERKS.

Sir,—I hear from Mr. Lodge, estate agent to W. H. Grenfell, Esq., Taplow Court, that phosphatic chalk has been met with at a point 870 yards N.E. by E. from the pit which I described in the Quart. Journ. Geol. Soc., vol. xlvii, p. 356 (1891). The section in the new excavation is given by Mr. Lodge as follows:—

		ft.	in.
Reading Beds	Clay with a layer of greensand and flints at its base	11	0
Upper Chalk	Chalk	8	0
	Phosphatic Chalk	2	0
	Hard white Chalk		
		21	0

It differs from the section at the pit in the phosphatic chalk being eight feet below the base of the Tertiaries instead of twenty feet, and in the phosphatic layer being apparently only two feet thick instead of eleven feet. There are no differences distinguishable under the microscope between the phosphatic beds of the two localities.

28, Jermyn Street, S.W. A. Strahan.

MISCELLANEOUS.

Mr. Thomas William Newton, the Assistant Librarian of the Museum of Practical Geology, Jermyn Street, after a service of nearly thirty-five years, has retired from office under the Treasury Order relating to age. Mr. Newton was joint compiler with the late Mr. Henry White of "A Catalogue of the Library of the Museum of Practical Geology and Geological Survey," published in 1878. This work contains references to about 28,000 volumes, and although a partial dismemberment of the library took place in more recent years, it is still considered a most important compendium to geological literature and other subjects of the natural sciences.